POWER

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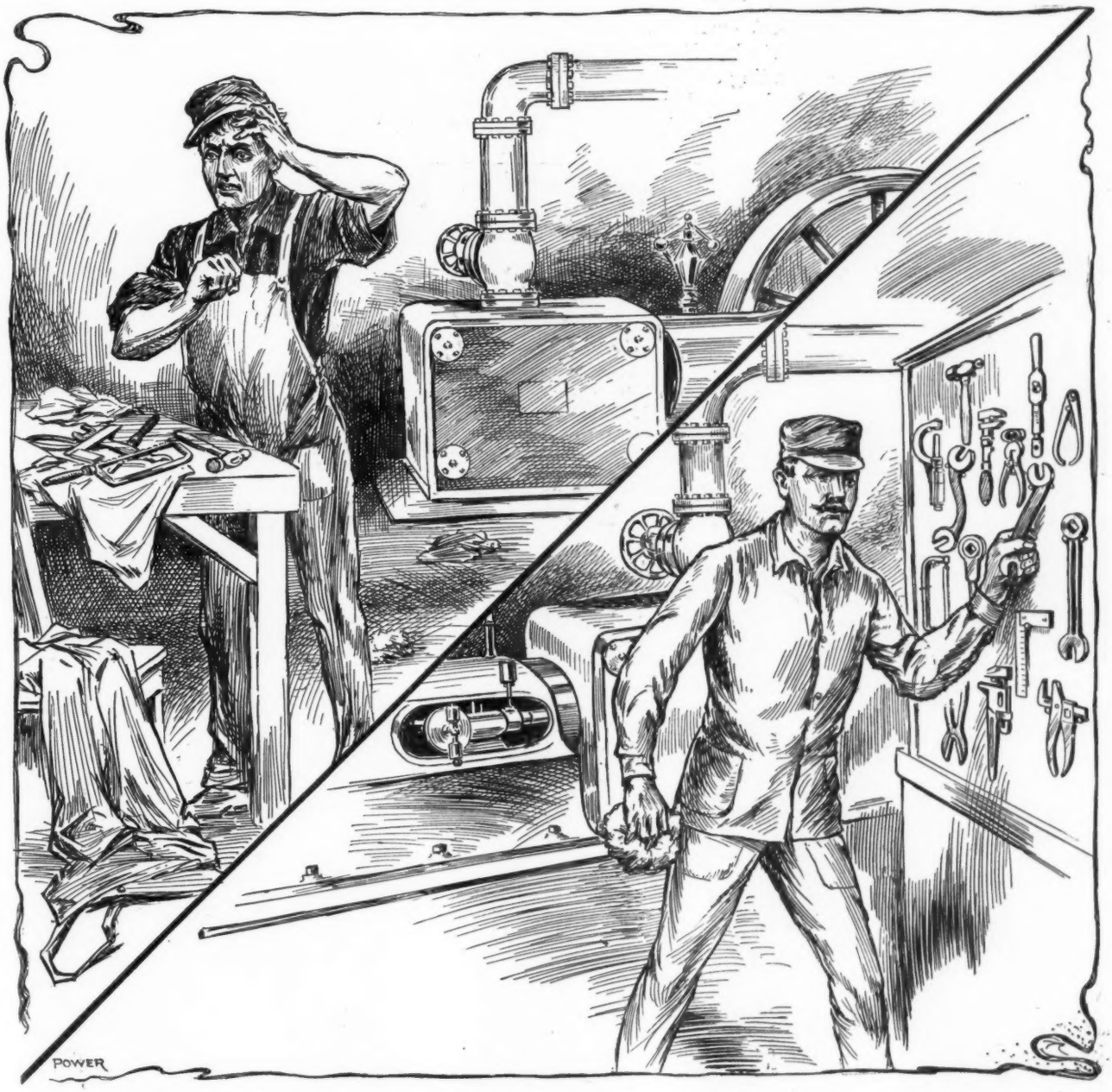


When moments are precious a well-kept tool-board is a treasure indeed

Performance of Low-Pressure Turbine Plant

By Charles H. Bromley

SYNOPSIS—Describes the equipment and gives interesting cost and performance data of a Corliss-engine-low-pressure-turbine plant, using an atmospheric cooling tower, and furnishing power for the Jenckes Spinning Co.'s plant, Pawtucket, R. I.

New England is a mighty busy section, and naturally economy is paramount. For generations engineers there have been brought up to a thorough realization of the importance of economical power-plant operation. The Jenckes Spinning Co.'s plant, Pawtucket, R. I., reflects the alertness of New England operating engineers and is a criterion by which to judge the best-conducted plants in that section. The plant operates day and night.

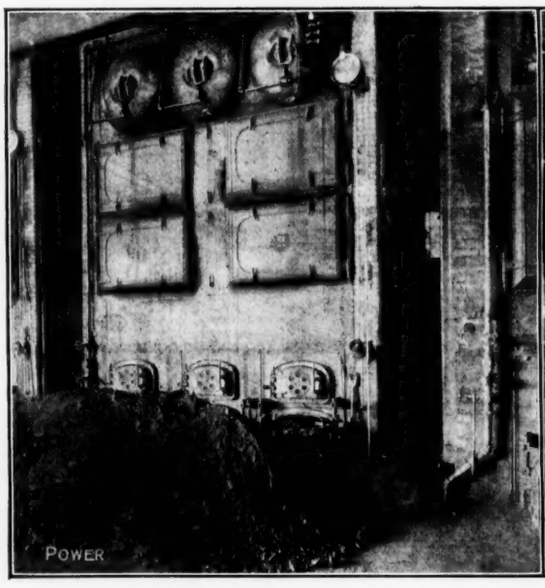


Fig. 1. Coal for the Test

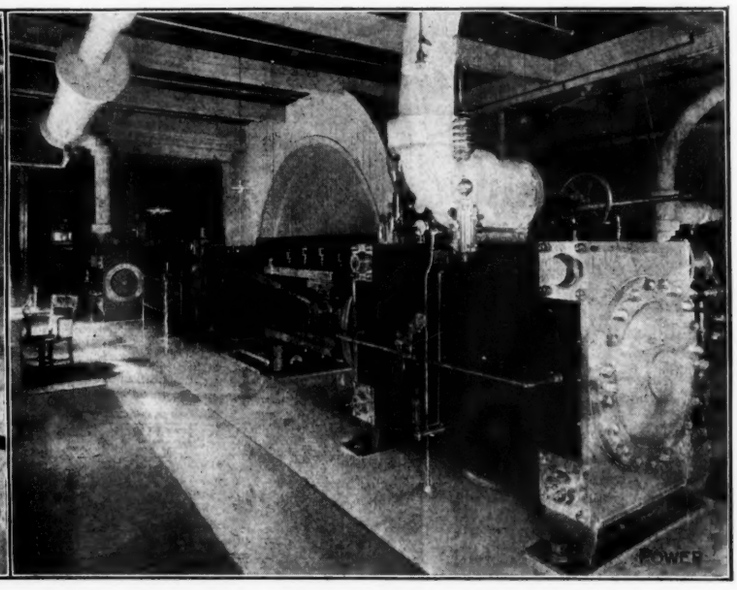


Fig. 2. The Two Simple Corliss Engines

Before the recent alterations and additions, this plant was furnished power by three Corliss engines running noncondensing. The company's chief output is tire fabrics and to keep pace with the automobile industry it became necessary to increase its power capacity.

Of the three engines of 850, 400 and 500 hp., the two former were retained, but the other having served its useful life, was discarded when the advisability of installing a low-pressure turbine became imminent. As its chief equipment the plant has now two 500-hp., one 250-hp. and one 400-hp. water-tube boilers; the simple Corliss engines mentioned; one 1000-kw., 60-cycle, three-phase, low-pressure turbo-generator excited by a 35-hp. induction-motor-driven generator; one auxiliary turbine-driven exciter; one 395-hp. synchronous motor; one surface condenser and one atmospheric cooling tower 20 ft. wide, 90 ft. long by 30 ft. high, which with the Rotrex air pump (the latter removes air and condensate in one cylinder) was guaranteed to condense 35,500 lb. of steam per hour and produce a vacuum of 3 lb. absolute pressure with an air temperature of 70 deg. and relative humidity of 70 per cent.; the guarantee was more than fulfilled. The feed pump is of the direct-acting duplex type exhausting into a closed heater fed by bleeding steam in from the pump and other auxiliaries.

The condensate, as usual, goes to the hotwell, the necessary makeup water being taken from the city mains, the total being measured on the way to the boilers by a 4-in. venturi meter.

The Boilers

The 520-hp. and the 250-hp. boilers are used for power purposes while the 400-hp. is for heating; all are hand-fired and furnished with natural draft. The coal is Crozer-Pocahontas, from the Crozer properties in McDowell County, W. Va. From this district, the coal runs about 2.72 per cent. moisture, 13 to 15.4 per cent. volatile, 77 to 86 per cent. fixed carbon, 4.4 to 5 per cent. ash and 0.55 to 0.77 per cent. sulphur. The heat value on the "as received" basis will average about 14,500 B.t.u.; when analyzed on the "moisture and ash free" basis, it runs up to as high as 15,860 B.t.u.

After the low-pressure turbine was installed it was desired to test the plant for efficiency under the usual day and night loads, the efficiency of the boiler plants, and the cost per horsepower-hour as determined by test over a seventy-two-hour period. The Massachusetts Institute of Technology was therefore called on and conducted the test, many of the data from which is given herewith.

A summary of the results obtained for the day, night and seventy-two-hour tests follows:

BOILERS

Boiler No.	Use	Hp.	Type	Heating Surface, Sq.ft.	Grate Surface, Sq.ft.
1	Power	520	B & W horizontal water tube	5085.5	90
2	Power	520	B & W horizontal water tube	5085.5	90
3	Power	250	B & W horizontal water tube	3900.5	60
4	Heating	400	B & W horizontal water tube	.....	90

RESULT OF TESTS

Boiler Plant

Heat of combustion of coal as fired: 14,680 B.t.u. per lb.	
Total equivalent evaporation from and at 212 deg. F.	
Day	28,200 lb.
Night	19,910 lb.
72 hours	24,300 lb.
Equivalent evaporation from and at 212 deg. F. per pound of dry coal:	
Day	11.44 lb.
Night	10.54 lb.
Test	11.10 lb.
Equivalent evaporation from and at 212 deg. F. per pound of combustible:	
Day	12.33 lb.
Night	11.34 lb.
Test	11.91 lb.
Equivalent evaporation from and at 212 deg. F. per sq.ft. of heating surface per hour:	
Day	2.02 lb.
Night	1.42 lb.
Test	1.66 lb.
Coal burned per sq.ft. of grate surface per hour:	
Day	10.34 lb.
Night	7.95 lb.
Test	9.25 lb.
Boiler horsepower developed, A. S. M. E. rating:	
Day	813.1
Night	576.9
Test	703.0
Maximum assumed possible error of test, per cent	1.88
Air per pound of coal from analysis of flue gas	28.2 lb.
Air required per pound of coal from the formula (12 C + 36 [H − O/8])	10.78 lb.
Excess air supplied, per cent	161.5
Heat carried off by flue gases per pound of coal	2,506 B.t.u.
Heat taken up by water in boiler per pound of coal	10,650 B.t.u.
Total heat furnished per pound dry coal	14,720 B.t.u.
Heat radiated per pound dry coal	1,564 B.t.u.
Heat carried off by flue gases, per cent	17.1
Heat loss by radiation, per cent	10.63
Thermal efficiency of boiler plant, per cent.:	
Day	75.4
Night	69.5
Test	72.8
Cost of 1000 lb. of steam	18.2
Cost per hp.-hr., cent	0.494
Cost per kw.-hr., cent	0.662

Entire Plant

Hp. output:	
Day	2,008.6
Night	867.7
Test	1,578.7
Pounds coal fired per hp. per hour:	
Day	1.23
Night	2.21
Test	1.41
Pounds steam per lb. coal as fired:	
Day	10.92
Night	10.19
Test	10.64
Pounds steam per hp. per hr.:	
Day	13.50
Night	22.4
Test	14.97
Thermal efficiency, per cent.:	
Day	14.15
Night	7.94
Test	12.4

An average of 23,600 lb. of water per hour was used in the power boilers, 27,135 lb. per hour during the day and 19,435 lb. per hour for the night. The heating boiler used an average of 5920 lb. per hour for the entire test, while an average of 5280 lb. per hour of makeup water was added to the total feed supplied. The equivalent evaporation per square foot of heating surface per hour for the seventy-two hours was 1.66, and the coal consumption per square foot of grate was 9.25 lb. This gave an equivalent evaporation from and at 212 deg. F. of 11.91 lb. of water per pound of combustible. The data covering the flue gases are made up of the totals of CO, CO_2 and O readings taken during the five shifts over which the tests extended.

FLUE GAS

CO	CO_2	O
0.20	17.80	21.2
0.50	27.55	88.8
3.40	55.40	77.8
0.20	30.40	90.8
1.20	63.60	114.1
Total.... 5.50	194.75	392.7
Average.....0.183	6.491	13.09

CO	0.18
CO_2	6.49
O	13.09
Total	19.76
N, per cent	80.24

Temperature flue gas = 427 deg. F.

	Per Cent.
Moisture	1.0
Ash	6.9
Hydrogen	2.8
Oxygen	4.2
Carbon	83.0
Sulphur	0.8
Nitrogen	1.3
	100.00

COST OF OPERATION PER HOUR (110 HOURS PER WEEK)

Repairs at $335 per month	$0.761 per hour
Oil and waste at $175 per month	0.398 per hour
Labor (day) at $130 per week	1.180 per hour
Labor (night) at $75 per week	0.681 per hour
Coal, weight burned per hour, 2219 lb., at $4.40 per ton	4.780 per hour
Total	$7.800 per hour

Cost per horsepower-hour $\frac{780.00}{1579} = 0.494$ cent

Cost per kilowatt-hour $\frac{780.00 \times 1000}{1579 \times 746} = 0.662$ cent

A heat balance for the seventy-two hours showed that of the available heat, 72.8 per cent. went for making steam, 17 per cent. was carried away by the flue gases and 10 per cent. was radiated away. The coal consumption per horsepower-hour as fired was 1.23 lb. for the day, 2.21 lb. for night, and 1.41 lb. over the seventy-two hours.

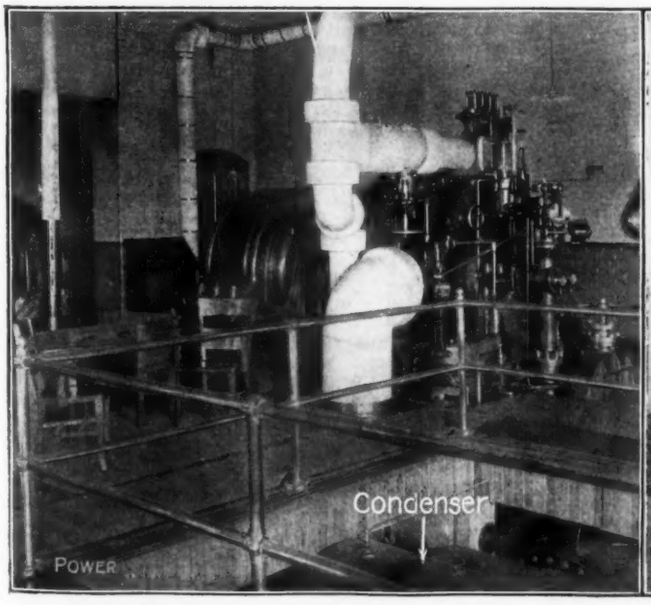


FIG. 3. THE 1000-KW. LOW-PRESSURE TURBINE

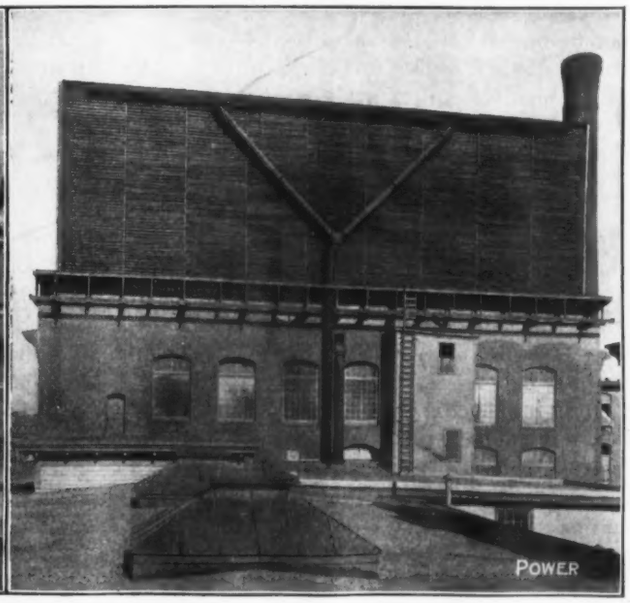


FIG. 4. ATMOSPHERIC COOLING TOWER ON THE ROOF

The quantity of steam per horsepower-hour was 13.5 lb. during the day, 22.4 lb. for the night, making it 14.97 lb. for the entire test period. The night results all through the test were comparatively poor, chiefly because at this time the engine and the turbine were running under half load.

The vacuum at the turbine was maintained very high, a trifle above 29 in. The barometer registered an average of 30.02 in. for the entire period, or an equivalent of 14.78 lb. atmospheric pressure.

Distribution of Purchased Power Charge

Tests made prior to the installation of the low-pressure turbine showed that for the 104-hr. week an average of 1021 hp. was being developed. This gives 106,184 hp.-hr. per week. The corresponding coal consumption was 355,990 lb., giving 3.345 lb. coal per horsepower-hour. These were the results obtained under noncondensing reciprocating-engine conditions. Before the low-pressure turbine was used, about 300 hp. was purchased from the city at $35 per horsepower, the purchased power costing at this rate $10,500 per annum.

PRINCIPAL EQUIPMENT OF JENCKE'S SPINNING CO.'S PLANT, PAWTUCKET, R. I.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Boilers	Water tube	520 hp	Power		Babcock & Wilcox Co.
1	Boiler	Water tube	250 hp	Power		Babcock & Wilcox Co.
1	Boiler	Water tube	400 hp	Heating		Babcock & Wilcox Co.
1	Engine	Simple Corliss	850 hp. 30x60 in.	Power	Belted; exhausts to low-pressure turbine	Harris Steam Engine Co.
1	Engine	Simple Corliss	400 hp. 24x48 in.	Power	Belted; exhausts to low-pressure turbine	Harris Steam Engine Co.
1	Turbine	Low-pressure	1000 kw	Generator drive—direct	R.p.m. surface condenser	General Electric Co.
1	Generator	Alternating current 3-phase	1000 kw.	Power and light	60 cycle, turbine driven	General Electric Co.
1	Motor	Synchronous	395 hp., 600 volts	Power	Belted to line shaft	General Electric Co.
1	Condenser	Surface	4800 sq.ft. tubes	Vacuum for turbine	With cooling tower; 29.3 in. vacuum in winter	C. H. Wheeler Mfg. Co.
1	Cooling tower	Atmospheric	90x20x30 ft.	Cooling condenser circulating water		C. H. Wheeler Mfg. Co.
1	Air pump	Wet type (Rotrex)		Surace condenser		C. H. Wheeler Mfg. Co.
1	Pump	Centrifugal		Circulating water, condenser	driven	C. H. Wheeler Mfg. Co.
1	Pump	Duplex plunger		Feedwater	Water from hot well	Henry R. Worthington
1	Heater	Closed		Feedwater		Henry R. Worthington

NOTE: The coal is furnished by S. P. Burton & Co., Boston, Mass.

The data given above for the seventy-two-hour test made after the turbine was installed show that 1578 hp. was averaged, and that the coal consumption was 1.41 lb. per horsepower-hour, giving a difference in fuel consumption between noncondensing-reciprocating engine and low-pressure turbine conditions of 3.345 — 1.41 = 1.935 lb. per horsepower-hour. If this last amount is multiplied by 1578, which represents the load in horsepower for a week, we get 3053.33 lb. or 1.375 long tons per hour. For the usual 104-hr. week the fuel saving on this basis amounts to 104 × 1.375 = 143 long tons. If the plant runs fifty weeks per year (allowing for holidays) the yearly saving is 143 × 50 = 7150 tons. As the price paid for the coal is $4.40 per ton, the yearly saving on this basis is $31,460.

But under the new conditions no exhaust steam is available for heating as there was when the plant was operating noncondensing. From the report we learn that for the seventy-two-hour test, conducted Apr. 1, 2 and 3, when the average outside temperature was 43.9 deg. F., there was an average of 47,736 lb. of coal burned in the heating boiler. After making due allowances for the factors influencing the consumption of coal for heating, one concludes that $10,000 per year is a liberally fair per annum charge. Prior to using the turbine the cost of purchased power (300 hp.) was $10,500 a year, and this charge, which ceased when the turbine went into service, goes a long way toward balancing the $10,000 required for heating now that the turbine uses the exhaust steam.

There is no true balance between these items, however, for the reason that when the power was purchased it cost $10,500 a year, which on the basis of a 104-hr. week, 50 weeks per year, gives 1,560,000 hp.-hr. or $\frac{10{,}500.00}{1{,}560{,}000}$ = 0.672c. per hp-hr.

At present, power is produced for 0.494c. per horsepower-hour, giving a difference of 0.672 — 0.494 = 0.178c., which, on 1,560,000 hp.-hr., totals $2776.08. As this 300 hp. is still being used it would not be correct to charge off the entire amount of $10,500. The amount to charge off is the difference between what this 300 hp. formerly cost and what it now costs. This difference is $2776, and is all that should be charged off in the plant's favor. If one were hypercritical, he could justly further reduce this amount by deducting sufficient to cover the interest, insurance and depreciation on 300 hp. of the 1000-kw. turbine. It is apparent then that instead of there being a saving of $10,500 to offset the $10,000 now needed for heating, there is only $2776, giving $10,000 — 2776 = $7224 to be deducted from the amount saved on the total power produced. Figured from the coal pile, this saving is $31,460, which minus the $7224 gives $24,236, exclusive of overhead charges, as gain on a yearly output of 1,560,000 hp.-hr.

Allowing $20 as the cost per kilowatt of the turbine installed and $7 per kilowatt for the condenser, cooling tower and pumps, the cost of the turbine installation becomes $27,000. If 12 per cent. is allowed for overhead charges, the net yearly saving is $21,000.

Use of Close Nipples—It is a difficult matter to make tight joints where close nipples are in sizes as large as 8 in., as there is not enough space for the use of a Stillson wrench. If the threads on the nipples are not perfect, considerable trouble will be experienced. They are also difficult to repair. Nipples for the larger sizes of pipe should be at least 8 in. in length.

Slippage of Reciprocating Pumps—It is folly to assume a general figure of 5 per cent. as the slippage of reciprocating pumps. As shown by test results the slip may be anything from 5 to 85 per cent., depending on the condition of the pump, the discharge pressure and piston speed.

If a pump is not kept in good order the slip may increase rapidly, even if the running conditions are kept constant. The following data are available concerning slippage tests on a 40-million-gal. pump:

	Slip, per cent.
June 10	1.7
June 26	5.2
Aug. 8	7.8
Aug. 15	12.4
Sept. 15	20.0
Sept. 18	22.9
Oct. 14	28.5

From such tests engineers are beginning to understand that they cannot assume the slip of their pump to be, say, 5 per cent. They are beginning to realize that there is a wide range of values of slip, and that for the economical operation of their plant they must determine how they can reduce slippage to a minimum.

First Large American-Built Humphrey Pump

By Charles C. Trump

SYNOPSIS—Details of construction of a 66-in. Humphrey pump for Del Rio, Texas. This pump is much simpler than the English design and the working parts have been standardized.

The first Humphrey pump to be installed in the United States of a size comparable with those in operation at Chingford, England, will be used for irrigation work on the G. Bedell Moore estate near Del Rio, Texas. In design it differs from the English type in several important details, the requirements of American pumping-engine practice, as well as experience with the Humphrey pump abroad, having made it advisable to simplify the construction. Furthermore, the opportunity for standardizing the working parts to fit a line of different-sized pumps has been seized and, wherever possible, as in the case of

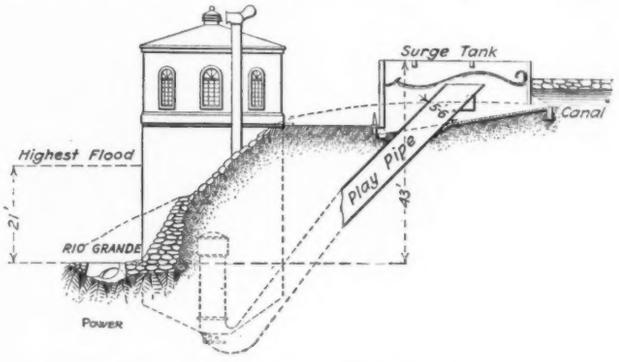


Fig. 1. Elevation of Installation

the water valves, that type of construction has been adopted which has stood the test in years of service.

As seen in Fig. 1, this pump has the shape of a short-legged V, the playpipe extending up the bank of the Rio Grande at an angle of 45 deg. with the horizontal from a two-part bend of 135 deg., upon which the water valves, and above them the vertical power cylinder, are set. The upper end of the playpipe is embedded in a concrete surge tank while the lower end, including the bends, is firmly held in reinforced concrete, which forms the bottom of the pump well; the walls are carried high enough to keep out the flood waters. Two gate valves control the flow from the river into this well, one to be operated and set by hand, the other to be regulated hydraulically by a float gear to maintain the proper level over the intake valves of the pump. On an operating floor, just above the intake water level, are the auxiliaries for starting, ignition, etc., while all the gas and exhaust piping is arranged vertically in the well, leaving space around the cylinder for convenience of operation.

A gas holder of 500 cu.ft. capacity has been provided to take care of the intermittent demands. Instead of a water-sealed gas receiver near the pump, a longer vertical tank of smaller diameter will stand against the wall of the well nearest the gas holder and will be connected to the latter above by short pipes, and below, through a check and throttle valve, with the gas belt of the pump. This receiver will be strong enough to withstand any explosions that may occur by reason of air in the gas line on starting; these, in any event, would probably blow the water seal of the gas holder. The short connection between the receiver and the pump will make it possible for the latter to draw a full charge on each stroke without appreciable reduction in pressure.

A 300-hp. Akerlund down-draft producer will furnish

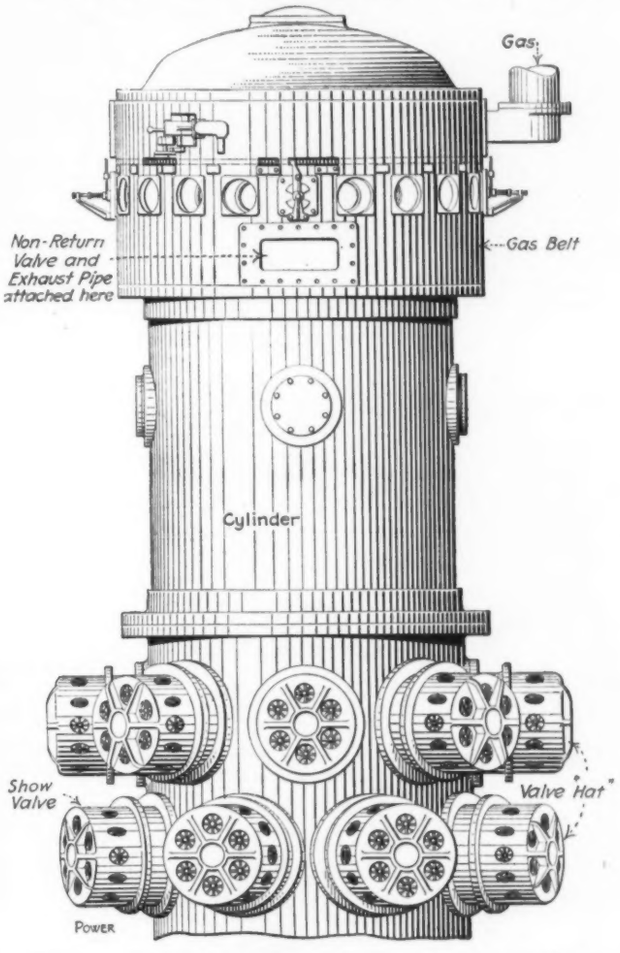


Fig. 2. Pump Assembled, Except for Play Pipe

gas for the pump and be capable of gasifying either soft coal or mesquite wood. The latter is obtainable by the necessary clearing of the land to be irrigated and will be used alone or in combination with semi-bituminous coal until the supply is exhausted, after which soft coal will be used entirely.

In a recent test of this producer with mesquite, the following results were obtained:

Gas generated per pound of wood	54.7 cu.ft.
Heat value of gas per cubic foot	114.5 B.t.u.
Wood per square foot of fire area	20.8 lb.
Wood per horsepower-hour	1.76 lb.

The cleaning apparatus will consist of only the usual two tower scrubbers—a coke scrubber and a dry scrubber. The gas will be supplied under pressure to the pump by means of a pressure blower. Water for cooling, scrubbing

and sealing the ashpits, as well as that vaporized in the producer, will be furnished by a triplex plunger pump. The power required to drive the producer plant auxiliaries will amount to 8 or 10 hp., and this, together with that required for the pump auxiliaries, will be furnished by

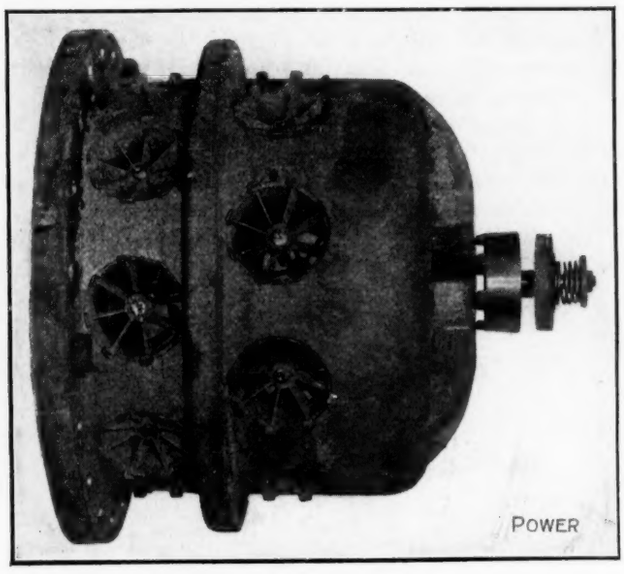


FIG. 3. WATER-VALVE CAGE

one of two gas engines of 15 hp., either of which will be sufficient for starting the plant and operating the necessary auxiliaries continuously.

The auxiliaries for the pump proper consist of a two-cylinder compressor for starting by air and gas, a pump for draining the well, and possibly a crane hoist for handling water-valve cages, etc.

Ignition apparatus and electric lights will be supplied by a direct-current generator driven by one of the gas engines. A duplicate set of storage batteries with interrupters to operate the jump-spark ignition has been provided with an arrangement for charging from the power and lighting circuit.

PUMP DETAILS

On top of the bend is set the box for the water-intake valves with its "hat" unit construction, as shown in Fig. 2. The box itself is a steel casting, weighing in the

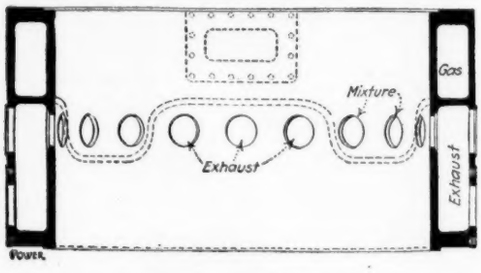


FIG. 4. MIXTURE AND EXHAUST BELTS

neighborhood of 3000 lb., and having openings for 16 hats or cages (see Fig. 3) containing 25 valves each, or a total of 400. The valve cages are semi-steel castings, into which the valve seats of manganese bronze are forced with a taper fit. The water valves are of the standard Underwriters' type and of 5 in. diameter, the rather large size being permissible in view of the slower speed and more gradual closing in the Humphrey, as compared with other pumps. Because of considerable sand in the river water, the valve disks will be made of a composition instead of rubber.

The cylinder above the water-valve box forms part of the combustion chamber, and is of riveted steel-plate pipe 66 in. inside diameter and 89 in. long. The plate is $\frac{15}{16}$ in. thick, with triple-riveted butt-strap joints inside and out.

The belt for gas valves shown in Fig. 2 contains the important working parts of the pumping engine. The belt itself is a steel casting weighing about 7500 lb., and is in the form of a double-walled section through which there are openings for the inlet and exhaust valves. In all, there are 20 of these openings, all at one level; 12 are for exhaust valves and eight for inlet valves. In order to have an even distribution of flow of the gases into and out of the cylinder, these openings are arranged in groups of two for mixture and three for exhaust separated by a dividing rib (see Fig. 4), which runs over the exhaust valves and under the mixture valves, around the annular space between the outer and inner walls of

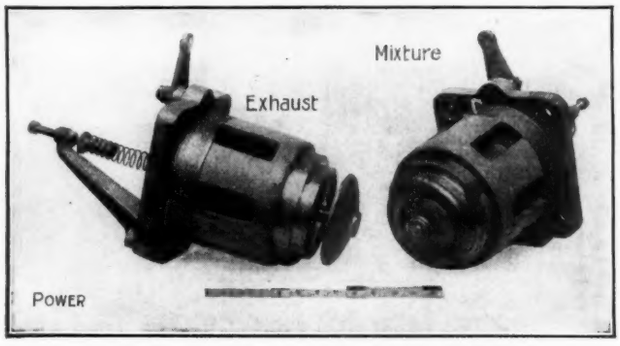


FIG. 5. INLET- AND EXHAUST-VALVE UNITS

the belt itself. Thus the belt is divided into an upper chamber, having a rectangular opening to which the gas pipe is connected, and a lower chamber with two larger openings for attaching the two nonreturn valves and the exhaust pipes. The reason for leading the exhaust gases downward is to allow any water carried with them to drain off.

Each mixture-valve cage is assembled as a unit and, as shown in Figs. 5 to 7, contains a double, flat-faced bronze valve of the mushroom type with a tubular stem. The outer end of the valve stem is threaded inside for a locking nut or head, which is fastened by an expanding bolt acting inside the quarter-threaded projection. The seat on which the valve works is also double faced, there being two concentric openings of equivalent area; the inner one is for air drawn directly through the cage cover around the valve stem and the outer one takes gas from the upper chamber of the belt. This arrangement keeps the tar or other impurities which may be carried in the gas as far as possible from the moving stem. On the cage cover is carried the locking lever hung on a pivot stud and so set as to allow the hooked end to wedge under the stem head, without the aid of a spring, and lock the valve tight. The upper end engages with a lug on the interlocking chain, which displaces the lever to unlock the valve.

The spring which closes the mixture valve is adjustable, and a throttle plate, Fig. 8, is provided for controlling

the supply of air to be mixed with the gas; a setscrew holds the adjustment.

The exhaust-valve-cage unit, also shown in Figs. 5 to 7, is interchangeable with that for mixture and differs from it in only a few details. The valve is also of the mushroom type, but has only one flat face at its outer circumference. This makes it lighter, which is advantageous, since the exhaust valve is closed with some violence by the rising of water in the cylinder. The valve is opened by an outside spring and much depends upon getting it open immediately at the end of expansion to atmospheric pressure, so as to draw in a full volume of scavenging air by the subsequent suction. This air is drawn in through the exhaust-valve cage directly. A spring-closed scavenging valve (see Fig. 7), which has its seat against the inside of the exhaust-cage cover, prevents the products of combustion from escaping into the air, and the nonreturn valves outside the belt keep the exhaust gases from re-

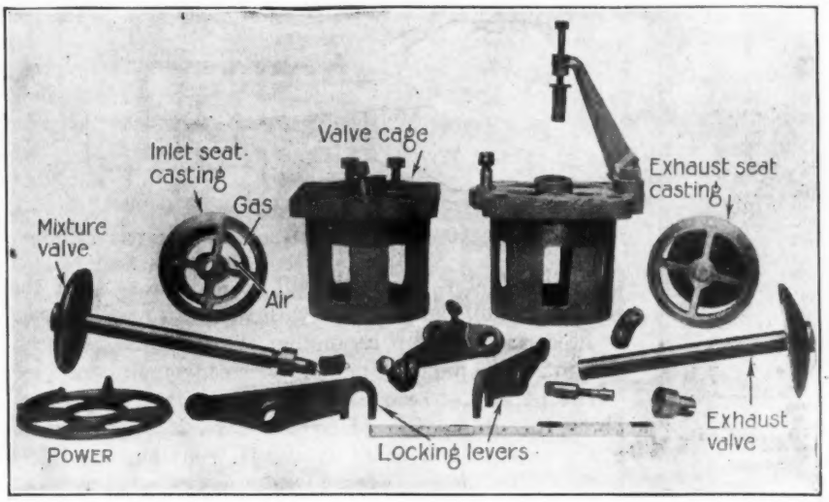


FIG. 6. VALVE UNITS DISASSEMBLED

turning into the cylinder instead of to the fresh air. In case the products of combustion left in the belt contaminate too much the small cushion volume, separate scavenging valves may be necessary on the steel-plate cylinder.

Upon the interlocking mechanism depends the operation of the four-stroke cycle. Bearing this in mind, it is necessary to lock the mixture valves during the expansion following the power stroke, and to lock the exhaust valves and unlock the mixture valves to admit gas and air during the charging stroke, which follows the first compression of the cushion and precedes the compression of the new charge. This is accomplished by a sprocket roller chain stretched about the belt above the gas valves, and carrying lugs which engage the locking levers of the exhaust valves in one direction and the mixture-valve levers in the other. The chain is moved by a shifter operated by a small spring-loaded piston in a cylinder connected with the play pipe. Every time the pressure in the play pipe rises, as it does both with the explosion and with the "cushion," the piston pushes the chain over. The mechanism is such that the explosion causes the chain to move toward the upper ends of the exhaust-valve locking levers and unlock the exhaust valves. The cushion simply pushes the shifter the other way and unlocks the mixture valves which were allowed to lock before by the action of gravity on the locking levers. The shifter is connected to the chain through a shaft to one of the sprockets on which the chain rides. Fig. 9 shows the head of a similar but smaller pump, with the chain and shifting mechanism attached.

A better idea of the operation of this shifter may be gained by reference to Fig. 10. When the pressure in the play pipe falls, the large spring forces the shifter piston to the right, drawing the spear-headed connecting-rod back away from the upper pin on the tee lever. A small, tension, toggle spring, connecting a pin on the lever with a pin on the spear-head, is not as strong as the large spring on the piston, but it immediately tends to pull the connecting-rod into a straight line of centers. Thus

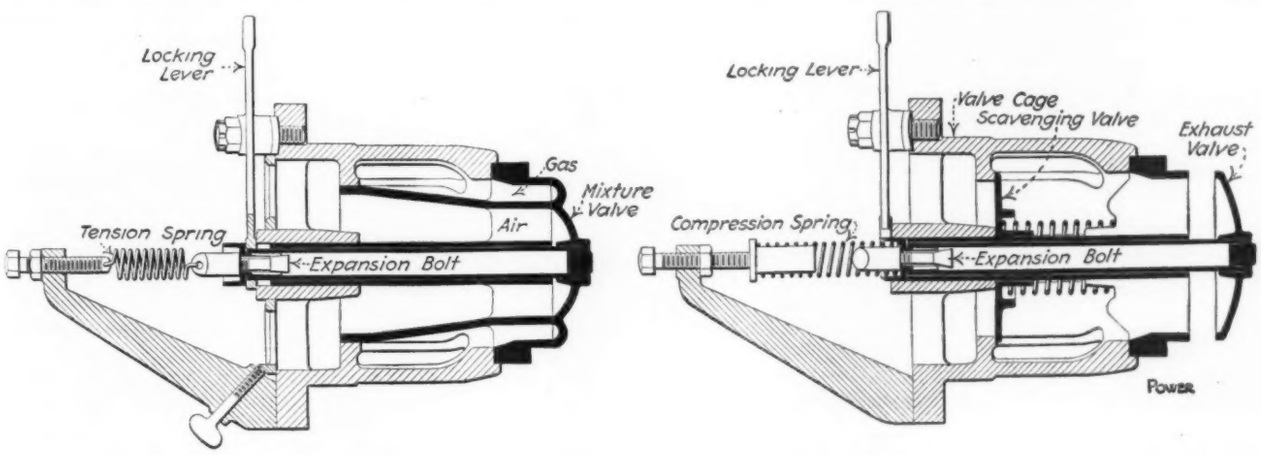


FIG. 7. SECTIONS THROUGH MIXTURE- AND EXHAUST-VALVE UNITS

when the piston has returned to its initial position, the socket of the spear-head is in a position to engage with the lower pin on the lever. The next rise of pressure, therefore, will push the lever over and thus move the chain, which interlocks the valves in the opposite direction. The sharp point on the spear-head and the small pin which is to be seen under the toggle spring near the center of

the tee lever make it practically impossible for the piston to move under the influence of pressure without engaging one or the other sides of the lever. In this way the alternate locking and unlocking of the mixture and exhaust valves is accomplished, and the duration may be

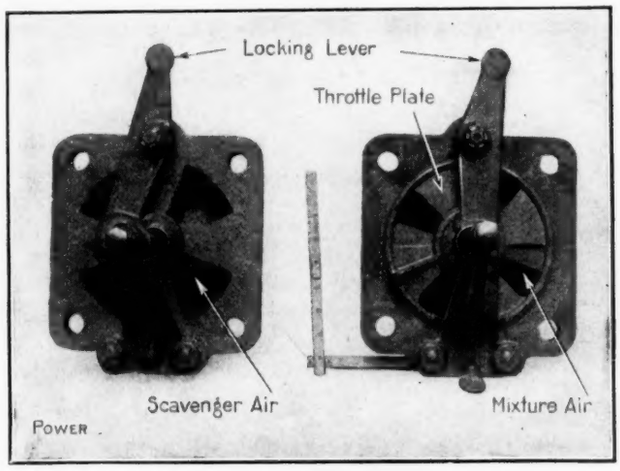


FIG. 8. SHOWING THROTTLE PLATE AND LOCKING LEVERS

varied to produce the correct effect upon the combustion.

To make the ignition system reliable under the conditions peculiar to the Humphrey pump has been no small task. The presence of water in the combustion chamber made electric ignition the only possibility, and beset that with difficulty. Both high-tension jump-spark and low-tension electromagnetic make-and-break or arc systems have been developed. Besides these two powerful systems, which are provided for each pump in duplicate, there is also a conventional set of automobile spark coils, plugs and storage batteries arranged to fire the initial charge in the cylinder by hand with a switch or push-button. All of the spark plugs for these ignition systems are placed in the cylinder head. The induction coils are fastened as near to their respective plugs as possible to reduce the danger of leakage of high-voltage discharges and are protected so far as possible from moisture.

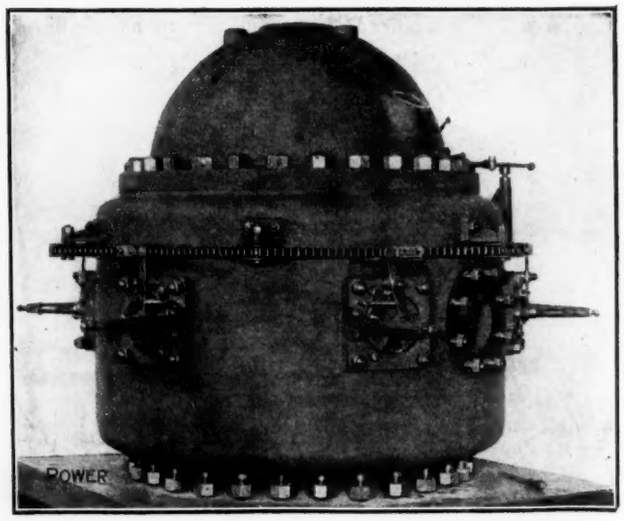


FIG. 9. GAS HEAD OF SMALLER PUMP, SHOWING CHAIN IN POSITION

In addition to the igniters the domed head is pierced with numerous holes to admit air and gas for starting. This is accomplished in a simple manner by pumping in a mixture by means of the two-cylinder compressor, pumping air and gas in proper proportions by separate pipes to a tee just outside the dome. The first cylinderful of inflammable mixture fired above

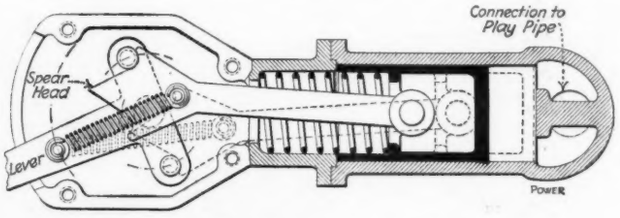


FIG. 10. SECTION THROUGH SHIFTER

the water in the play pipe will be enough to start the column and fill the play pipe with water; it may not even be necessary to pump in another charge under compression to get the pump in motion for steady operation.

The pump has been designed and built by the Humphrey Gas Pump Co., of Syracuse, N. Y. under Humphrey patents and those of W. H. Smythe, the latter having done pioneer work in this line.

Indicated Power from Diagram of Proportional Length

BY J. S. A. JOHNSON

In a direct-acting steam pump the stroke is not of constant length. Consequently, in determining the power with an indicator, the usual formula

$$\frac{PLAN}{33{,}000} \qquad (1)$$

does not apply unless the length of stroke L be measured at the time the diagram is taken.

A better plan is to ascertain the piston travel corresponding to one inch of length of indicator diagram, either measured or calculated from the reducing motion, and modify the usual formula.

Let

L = The length of stroke in feet;
A = Area of the piston in square inches;
N = Number of strokes per minute;
S = Scale of indicator spring;
m = Length of the diagram in inches;
$\frac{L}{m} = R$ = Piston travel, per inch of diagram length;
a = Area of the diagram in square inches.

The mean effective pressure P being equal to $\frac{aS}{m}$, then the familiar formula becomes

$$hp. = \frac{aSLAN}{m \times 33{,}000} = \frac{aSRAN}{33{,}000} \qquad (2)$$

It will be seen from formula (2) that in calculating the power it is only necessary to count the number of strokes per minute and measure the area of the diagram. This method would in fact be more convenient for calculating the power of all types of engines, as the value of the product SR in formula 2 is simply the number of foot-pounds per square inch of piston area per stroke for each square inch of the diagram.

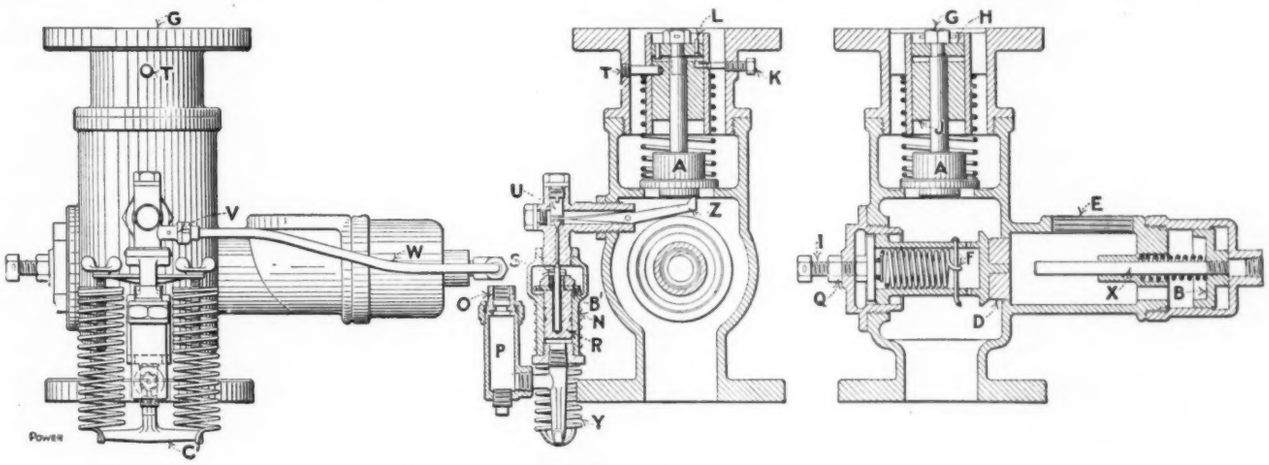
New Starting Unloader for Motor-Driven Compressors

A starting unloader for motor-driven compressors, in which the motor current is cut out or in to stop or start the compressor when a maximum or minimum load is reached, has recently been put on the market by the Yarnall-Waring Co., Chestnut Hill, Philadelphia, Penn.

The unloading action is obtained by the velocity of the air pressure passing through the chamber and by the variation of the receiver pressure.

The compressor is unloaded when the speed is reduced about twenty-five per cent.; by this action any recoil on the last revolution experienced when stopping against a load is obviated.

When the motor starts, the air is bypassed to the atmosphere until the desired speed is obtained, at which point the bypass valve closes and the air passes to the receiver until the predetermined pressure at which the current is cut out is reached. Then the bypass is opened by the receiver pressure and trigger against the unloading piston. With the compressor unloaded, the intake air has then a practically free passage through the cylinder, with a resultant cooling effect until the machine stops.



DETAILS OF THE DESIGN OF THE UNLOADER

The different loading and unloading operations are dependent upon the speed of the machine and are automatic. When the current is cut out and the compressor slows down, the bypass valve opens automatically and unloads before the compressor stops. When the current is cut in, compression does not occur until the motor has obtained the desired speed.

The advantage of this unloader is that a compressor so equipped will require less power to start. Such a compressor can therefore be driven by a motor of less power than is ordinarily used. The operating parts are few and simple, and consist of a bypass valve *D*, a check valve *A*, unloading piston *B*, and the trigger *C*. The detailed operation, referring to the illustrations, is as follows:

The air from the compressor discharge port enters at the bottom of the unloader and passes through the open valve *D* to the atmosphere at *E* until the bypass valve *D* is closed by the velocity overcoming the tension of the spring *F*. The air then lifts the check valve and passes to the receiver, connected at *G*. The check valve *A* is controlled by the dashpots *H* and *J* to prevent its seating at every stroke; the time of seating is regulated by the vent screw *K*. The small valve *L* is a vacuum breaker to allow the check valve to lift freely. *T* is a fixed pin for holding the dashpot bushing in place.

The receiver pressure to operate the trigger mechanism enters the trigger cylinder *N* through the port *O* and filter *P*, and acts on the piston *R* to close the bleeder valve when the pressure is within 3 lb. of the maximum.

As soon as the motor current is cut out and the speed is reduced about 25 per cent., the check valve *A* seats and presses down the lever *Z*, lifts the pilot valve *U*, admitting pressure from the chamber *V* through the tube *W*, behind the piston *B*. The bypass valve *D* is forced open by the piston rod *X*.

When the receiver pressure has dropped about 3 lb., or any predetermined amount, the tension springs *Y* pull down the trigger piston *N* and the bleeder valve *S*. After starting again and the velocity has closed the bypass valve *D*, the accumulating pressure in the valve chamber blows out of the pilot valve *U* and the bleeder valve *S* until the check valve *A* lifts and the lever *Z* releases the pilot valve and allows it to close.

The tension on the springs *Y* is usually so adjusted that the pressure under the piston *N* closes the bleeder valve *S* when within 3 lb. of maximum and opens the valve when the pressure has dropped that much. To prevent any possible leakage past the pilot valve *U* from acting on the piston *B* and forcing the bypass valve *D* open, a minute hole is drilled at *V* to permit this air to escape.

Just before unloading occurs, the bleeder valve *S* closes and allows the full pressure to act on the piston *B*. While loading it is kept open to prevent the pressure from acting on the piston. The baffle washer B' is to prevent any cylinder oil which may blow out of the bleeder valve from coming in contact with the piston *R*. The unloader is generally placed on the discharge port of the compressor cylinder, but it may be put anywhere in the discharge line near the cylinder, and its efficient operation will not be hindered.

The adjustment of the unloader to the required conditions of the compressor is particularly simple. When the compressor is near the desired speed, the locknut *Q* is backed away and the thrust screw *I* is turned in, thus moving the bypass valve *D* toward its seat until it is closed automatically by the velocity of the escaping air; then the locknut is set up.

When the receiver pressure is within about 3 lb. of the maximum or cutting-out point, the springs on the

trigger are so adjusted that the pressure under the piston R closes the bleeder valve S, and, conversely, opens the valve when the pressure has dropped the same amount. After these two single-spring adjustments have been made, the compressor is ready for its regular work under the required conditions of speed and pressure.

The unloader in no way controls the starting and stopping of the motor; it merely unloads the compressor and keeps it so until it is again started and up to the required speed. The control of the motor current is accomplished by some one of the standard controlling switches and circuit-breakers.

Methods of Suspending Motors

By Francis H. Davies

SYNOPSIS—Practical ways of attaching electric motors to walls, ceilings or columns so as to secure both rigidity and neat appearance.

The placing of electric motors in out-of-the-way positions on walls, ceilings or columns often introduces problems of some little difficulty. Generally speaking, many ways of meeting such cases will occur to the practical man, but the less experienced erector, having little in the way of precedent to guide him, may find the accompanying illustrations of service.

Wall suspension introduces the least difficulty, but it is essential first of all to make sure that the wall or beam is capable of withstanding the strain, not only of the belt pull, but also of continual vibration. There are no rules governing the former point, which must, therefore, be left to experience, but the effects of vibration may be diminished to a large degree by inserting a good hair felt or rubber pad between the base of the motor and the wall. In such cases it is necessary also to bush the bolt holes in the base with a similar substance and to insert suitable isolating washers under the iron washers to prevent vibration being transmitted through the bolts. Figs. 1 and 2 show, respectively, the simplest and most usual methods of bolting to timber and brick or concrete walls. They are self-explanatory and it is necessary only to mention that the anchor plates on the outside of the wall should be of large area so as to distribute the pull as much as possible. Expansion bolts may be employed for small motors, but for those of any size the bolts should extend through the walls.

A smooth seating for the motor is very necessary, otherwise it will be likely to set up vibration and become loose as the projections upon which it rests wear down. For this reason it is always advisable to interpose a piece of felt as before mentioned, or, failing this, a sheet of lead will be satisfactory. If it is essential that the motor should operate in its normal upright position, it must be installed upon a bracket mounted on the wall, as in Figs. 3 and 4. The first of these is of wooden construction and is useful for small motors. It is composed of two brackets placed a suitable distance apart and fitted with a substantial wooden platform to which the motor is bolted. The members are held together by coach screws, but the joints should be as accurate as possible in the interests of strength. If preferred, a piece of boiler plate makes an excellent substitute for the wooden platform. The bracket shown in Fig. 4 is constructed of angle iron and is suitable for any size of motor that would be installed in such a position. It is best to rivet the shelf to the angle-iron supports, using rivets with countersunk heads to allow a smooth surface. If the motor is comparatively light it is possible to dispense with the bottom struts, stout angle steel being used to support the bracket. In this case, however, it is better to substitute two triangular or gusset-shaped pieces of plate, riveting a piece of angle iron to the upper edge to allow the platform to be bolted down and another to the edge that bears on the wall to carry the fixing bolts. Practically every wall fixing problem may be met by one or other of these means with slight modifications.

The fixing of motors to ceilings or horizontal beams may introduce a great variety of problems. Attachment to timber rafters or beams is generally a simple matter which, in the ordinary way, calls for no comment, but unusual conditions sometimes arise, such as those depicted in Figs. 5 and 6. The pitch of the bolt holes in the motor base will seldom be found to correspond to the pitch of the floor beams, and ordinarily this difficulty will be met by bolting a timber platform to the latter and fixing the motor to this. Should such a method be undesirable or impossible, an alternative means employing steel brackets is shown in Fig. 5. They may have to be specially made, and almost certainly will have to be specially drilled, but the method is worth a little extra expense as it is both rigid and neat. It also permits of a fairly wide range of bolt-hole pitch, as the brackets may be placed either outside the beams or inside if the pitch of the latter is too great.

The design shown in Fig. 6 was employed where it was desired to suspend a motor from the ceiling, but at the same time to operate it in its normal vertical position. The use of structural steel would make a neater and better job than timber, but the latter is cheaper and will be satisfactory if the work is well carried out with seasoned material. It is desirable to place the motor as close to the ceiling as possible, so as to keep the vertical struts short and afford maximum rigidity. It is also well to place a pad of hair felt under the motor base, as this will minimize vibration, which, in course of time, will deteriorate any wooden structure.

Attaching to steel girders is generally straightforward work and it is, therefore, unnecessary to touch upon it here; Fig. 7, however, shows a convenient form of bracket which may be employed where an extension of the girder flange is necessary.

The increasing use of concrete in buildings introduces difficulties in motor fixing, which must be met by special means. If the architectural and engineering design can be worked in together, bolts or sockets can be placed in the ceilings as the building work proceeds, thus saving trouble and expense. This, unfortunately, is not always possible and more often the erector has to deal with a finished building. Figs. 8, 9 and 10 illustrate methods which

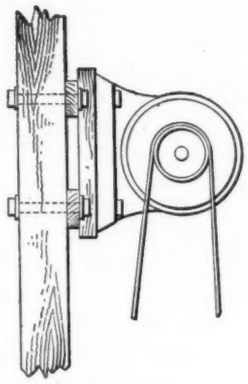


FIG. 1

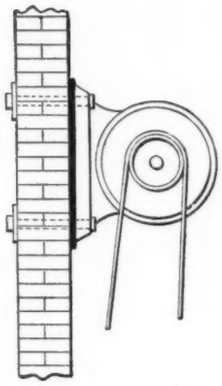


FIG. 2

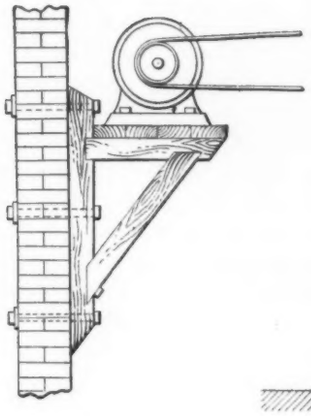


FIG. 3

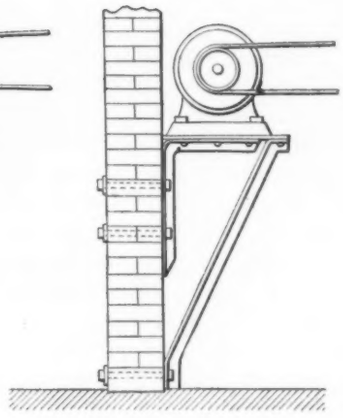


FIG. 4

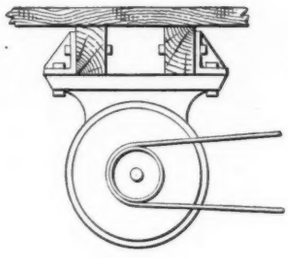


FIG. 5

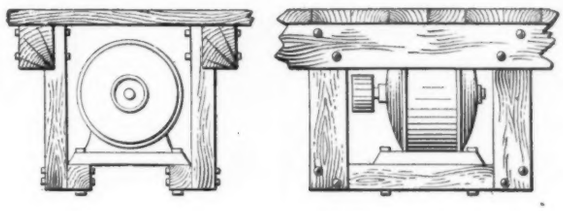


FIG. 6

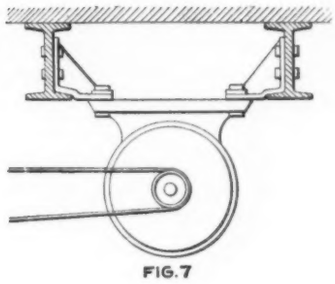


FIG. 7

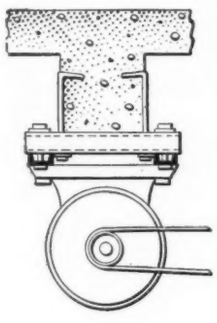


FIG. 8

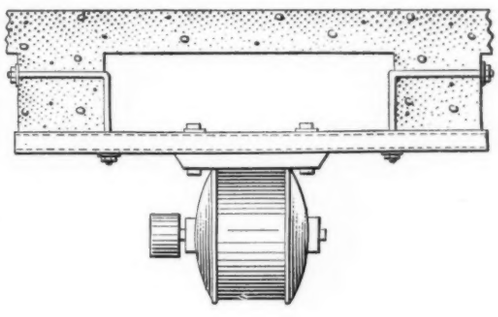


FIG. 9

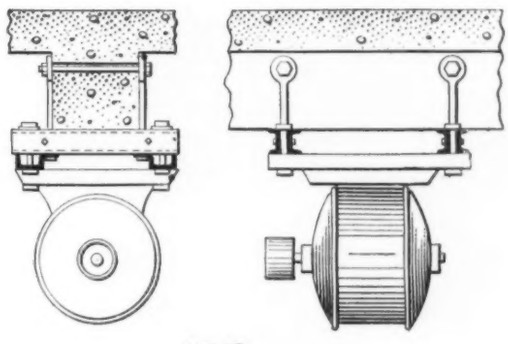


FIG. 10

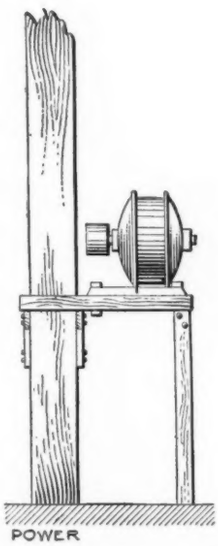
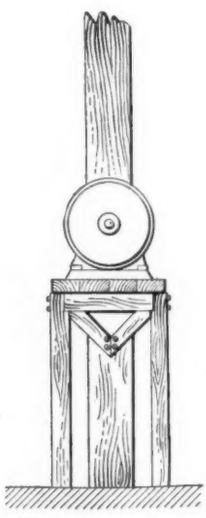


FIG. 11



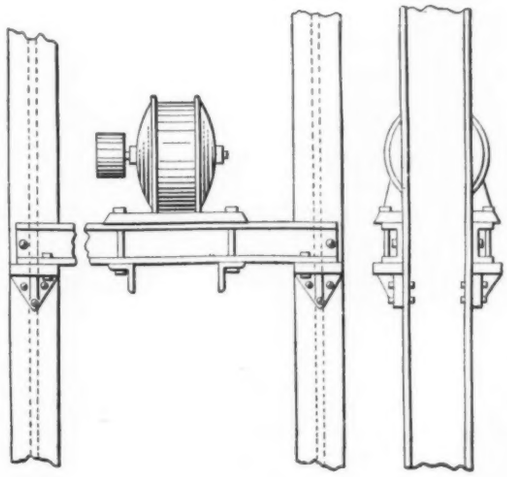


FIG. 12

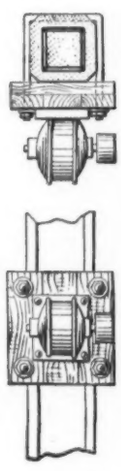


FIG. 13

VARIOUS METHODS OF SUSPENDING MOTORS

have been employed in the attachment of motors to concrete beams. The arrangement shown in Fig. 8, which involves the use of ¾-in. hooked bolts sunk and grouted into specially drilled holes in the concrete, is suitable for light weights and small powers. The cradle is built up of channel iron in the manner shown, but may be equally well constructed of timber if preferred.

Fig. 9 is a design suitable for larger powers, L-bolts being employed, but it is inferior to the method shown in Fig. 10, which is strong enough to meet any ordinary case of ceiling suspension. Eye-bolts are used in conjunction with a bolt piercing the concrete beam. The stringers are formed of iron channels placed back to back and the cross-pieces which directly support the motor are also of channel section. These will probably not be required in every case, for if the size of the motor base permits, it can be bolted directly to the main stringers, thus economizing in height, material and labor. One or other of these designs modified to suit the actual conditions should meet all ordinary cases of ceiling suspension from concrete beams.

In the attachment of motors directly to columns or to structures supported by columns, the weight and horsepower of the motor and the nature of the columns must be taken fully into account. Fixing direct is only advisable where small powers are concerned and in the case of timber beams a small wooden bracket is easily constructed. It is safer, however, to strengthen the arrangement by the addition of vertical supports, and a column bracket designed on these lines is illustrated in Fig. 11. Here the weight is divided between the column and the legs of the bracket, which should be tied to the floor or to the base of the column. Such brackets should be kept as low as possible in order to increase their stability. Brackets for structural-steel columns present no difficulty, as they are easily constructed out of angle iron and plates, the sections being riveted together and bolted or riveted to the girder flanges. It is advisable only to support comparatively small motors in this manner, and the larger sizes should be carried on stringers of structural steel, erected between two convenient columns, on the lines indicated in Fig. 12.

Attaching to concrete columns is a more difficult matter, and it is undesirable to install anything but small motors in such a location. A simple but effective method suitable for a light motor is illustrated in Fig. 13. Two U-shaped ¾-in. bolts encircle the column and a stout timber base board is thus securely bolted to it. In order to prevent slip the bolts should be sunk into the back of the column as shown; failing this, vibration will in time weaken the hold unless the motor is very small. It is obvious that the methods illustrated in Figs. 8, 9 and 10 may also be applied in securing attachment to concrete columns if the details are suitably modified.

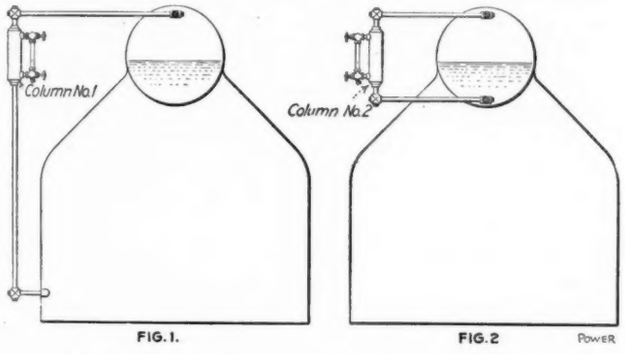
Direct and Indirect Labor—We often take offense at something merely because the thing is misnamed, says "American Machinist." "Nonproductive labor" is a term that carries with it a wrong idea. It is a misnomer. The contrast is **productive** against **nonproductive.** And the natural conclusion is that work so classed should be dispensed with merely because it is labeled "nonproductive." The substitute terms that are fortunately growing in favor are "direct labor" and "indirect labor." They are descriptive and convey no wrong idea. Therefore say direct instead of productive, and indirect instead of nonproductive labor.

Observations of Boiler Water Columns

By R. N. Robertson

The following observations were made on one of a battery of seven boilers in an effort to account for the large amount of water that passed over to the engines whenever there was a sudden heavy overload. This took place with apparently a moderate amount of water in the boilers.

The original arrangement of the water column with the connections is shown in Fig. 1. The later arrangement is shown in Fig. 2. Since making the original observations of the apparent water level as shown by the two glasses on the original installation, all the glasses have been changed and connected as shown in Fig. 2, and relying upon the water level as indicated by the present arrangement very little water has been carried over.



Methods of Connecting Water Columns

OBSERVATIONS

Gage Pressure, Pounds per Sq.In.	Water Level—Col. No. 1, Inches	Water Level—Col. No. 2, Inches	Remarks
Boiler cold ...	3¾	3¾	Fire just started.
26	3⅛	5¼	
40	3	5½	
50	2¾	6	
60	2¾	6	
80	2½	6¼	
100	2	6½	Boiler not on the line.
100	1¾	6¾	Boiler working on the line.

The tabulated observations show that column No. 1 (as originally installed and connected) indicates about 5 in. less water than is actually in the boiler drum under working conditions.

A calculation based on the temperature of the boiler water at 100-lb. gage pressure (atmospheric pressure about 12 lb. abs.) and a temperature of 100 deg. F. in the lower connection to the water column, indicates that No. 1 column (as originally installed and connected) will show about 4.6 in. less water than is actually in the boiler. This is due to the difference in temperature of the water in the upcast leg of the boiler and that in the downcast leg from the bottom of the water column. In this case the apparent water level was 3½ ft. above the point at which the downcast leg from the water column entered the water leg of the boiler.

The observations emphasize the necessity of making the connections to the water column, and especially the bottom connection, as short and direct as possible. Particularly should there be avoided long vertical pipes leading from the bottom of the column and making connection low down on the boiler.

Apparently No. 2 water column is a little affected by

the circulation in the boiler, due to rapid steaming, as the apparent water level rose ¼ in. when the boiler went into active operation on the steam header. This circulation also apparently affected No. 1 column also but, as might be expected, in the opposite direction, the water level in this column dropping ¼ in. when the boiler began to steam freely.

At the time the observations were made column No. 1 and column No. 2 were simultaneously in use on the same boiler.

Refilling Commutators

By Norman G. Meade

SYNOPSIS—Directions for making and assembling commutator segments from scrap copper, with the tools ordinarily available around a plant.

Where there are many direct-current motors in use, refilling of worn-out commutators becomes a factor of considerable importance. The delay in securing new parts from manufacturers, especially if the machine is several years old, often causes serious annoyance. This consideration and the matter of reducing the cost of repairs led the writer to devise a simple method of refilling commutators at a comparatively small cost, utilizing scrap copper wire for the raw material.

The first operation was to dismantle the old commutator, being careful to preserve the insulating rings at the ends, if possible. From one of the worn segments the actual shape of a new segment was determined and a sketch drawn. This was turned over to the die-maker, who made a die similar to the one shown in Fig. 1, the recess or groove corresponding to the shape of the desired segment.

From the scrap pile discarded copper wire of the proper size was selected and the insulation burned off, which, at the same time softened the copper. The wire was then cut into lengths a little greater than the required length of the finished commutator and the die and the copper stock were taken to the blacksmith shop. The upper steel block of the die was raised sufficiently to insert a piece of the copper and the die placed under the steam hammer.

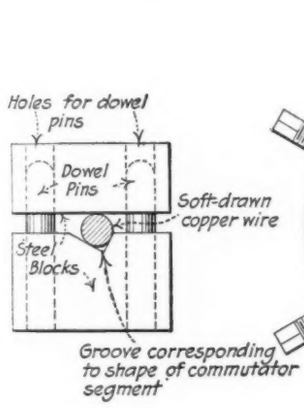


FIG. 1

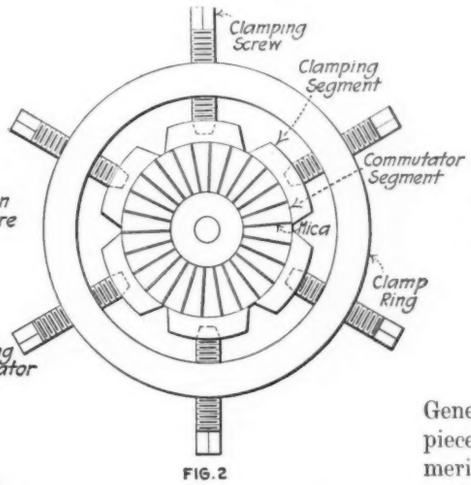


FIG. 2

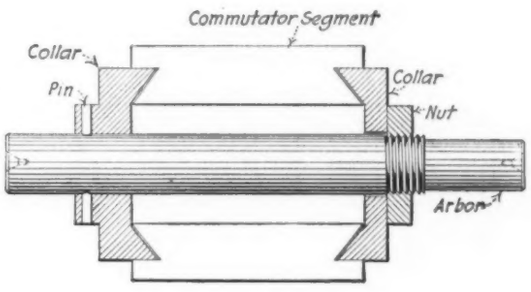


FIG. 3

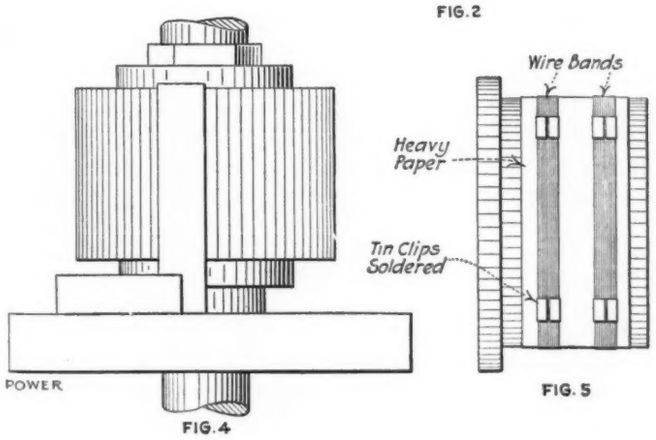


FIG. 4

FIG. 5

Method of Forming and Clamping Segments

Generally one or two blows were sufficient to shape the piece of wire and the new blank was ready. The hammering process hardened the copper sufficiently for use.

A suitable clamping device is necessary for assembling and holding the segments in the proper form while boring out the center and turning the grooves in the ends. A serviceable clamp, shown in Fig. 2, can be made from odds and ends always found around a shop. From sheet "micanite" the oblong pieces of insulation should be cut and the segments and insulation assembled in the ring clamp and tightened up. The clamping ring is next placed in a lathe chuck and the ends and interior of the segments finished.

If the shell of the old commutator cannot be conveniently used, a temporary arrangement for holding the segments can be made as in Fig. 3, which is an arbor with a tight and a loose collar that conform in shape to the finished ends of the segments. This device should be attached to the assembled segments before the clamping ring is loosened. The arbor with the segments is then placed in a lathe and the outside of the segments finished. The segments should be turned down to within about a half inch from one end, so as to leave a shoulder in which slots can be cut to receive the lead wires.

The arbor and segments should then be transferred to a milling machine for cutting the slots in the shoulder. Before turning the outside of the segments, it is well to make sure that all are parallel to the axis. This can be accomplished as in Fig. 4. Insert one end of the arbor

into a hole in any true surface and place a try-square as indicated. By sighting along its edges, one can easily determine whether the segments are in line. If not, they can be driven into position by slightly loosening the clamping nut and using a small cold-chisel and a light hammer.

It is advisable to make up several sets of segments at one time, so as to have a reserve stock; the assembled segments can be held in shape for instant use by banding them as in Fig. 5. The banding is done after the turning is completed, but before the segments are removed from the clamping collars on the arbor.

By following this method of refilling, new commutators can be made at small cost and without delay.

Adapting Old Equipment to New Use

By D. P. Morrison

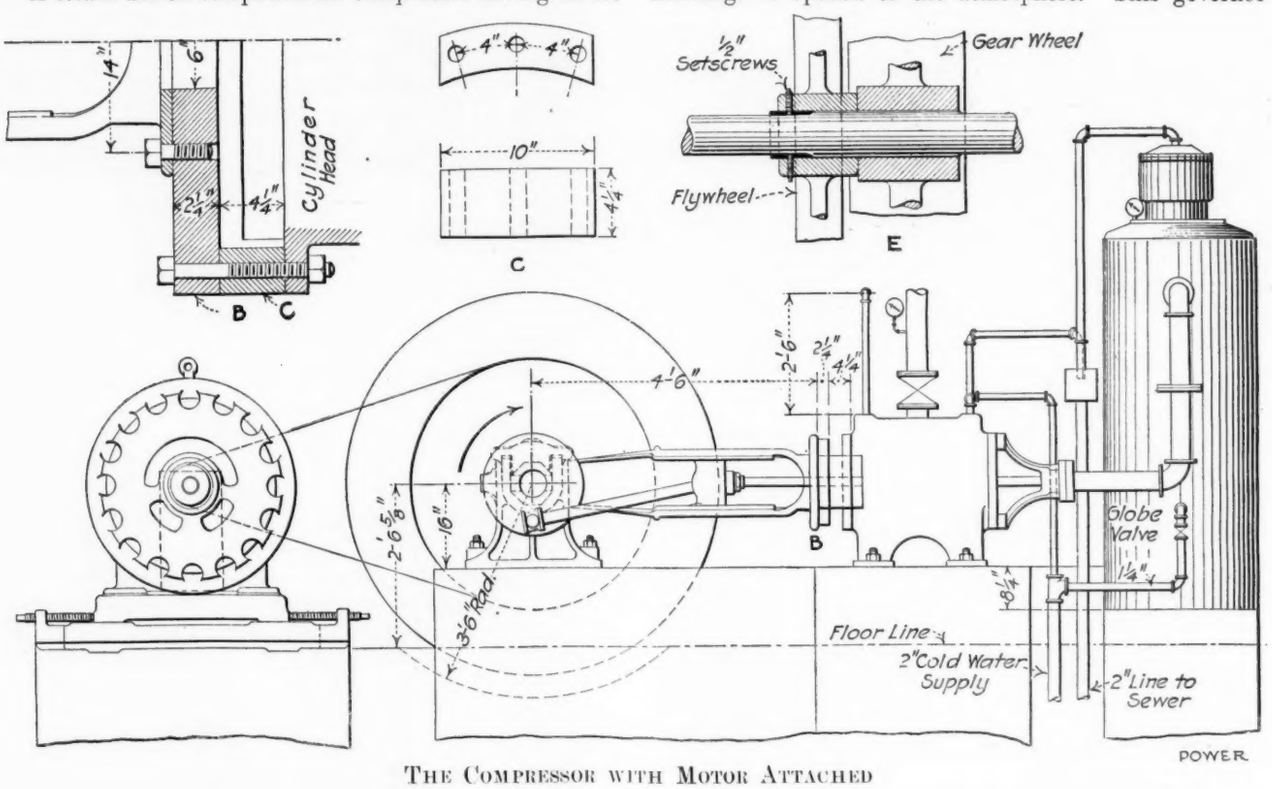
In any large establishment, changes in requirements or load often render an individual unit unsuitable for further use in a given location, and the problem of fitting such equipment to other needs and locations is often difficult of solution. The following is an example:

A steam-driven compound air compressor having 12-in. duplex steam cylinders and air cylinders of 11¼- and 18¼-in. bore by 14-in. stroke, was released. A shortage of air in the car-repair yard elsewhere required increased capacity, but as no steam was available there, this compressor was useless unless some other drive could be arranged. An electric drive for the compressor was worked out, as illustrated. In the original machine the steam cylinder on each side was between the air cylinder and the frame girder, and owing to the difference in diameter between the steam and air cylinders, the girders could not be attached directly to the latter. It was necessary to design a yoke *B* to which the girder could be bolted through extension blocks *C* to the air cylinder. With the rods cut to suit the new position of the air cylinders, the machine was ready for the motor drive.

It was decided to use a silent-chain drive of sufficient size to overcome the difficulties often had in compressor work and reduce the speed to 125 r.p.m. to favor the equipment and keep the horsepower down. The 580-r.p.m., three-phase, 60-cycle motor gave a ratio of about 4.6 to 1 and a chain speed of about 1450 ft. per min. A 1½-in. pitch chain 9 in. wide at this speed is ordinarily rated by the builder at 100 hp., but this figure was not considered liberal enough for a compressor drive, so a chain 14 in. wide and sprockets without spring centers were put on.

Another problem was to secure room for the sprocket of this width between the flywheel and main bearing without making another crankshaft, because the large part of the shaft was not long enough to accommodate both wheels. A collar or sleeve was shrunk on the shaft and turned down to the large size of the shaft. After the hub was clamped on, it was held in place by three ½-in. setscrews on each side, extending through the sleeve.

The control is of the unloading type in which the low-pressure intake is entirely closed and the high-pressure discharge is opened to the atmosphere. This governor unloads the motor to 15 per cent. of full load and is set for a ten-pound variation. For example, it unloads at 90 lb. and runs unloaded until the pressure drops to 80 lb., when the compressor again takes the load.



The Compressor with Motor Attached

This compressor has now been in continuous operation, ten hours per day, for four months without any evidence of distress; in fact, its upkeep is less than for a similar steam-driven machine.

A Test for Pump Valves—Leaks in pump valves will show by the pump failing to maintain a vacuum within itself when the suction valve is closed.

The Universal Unaflow Engine

SYNOPSIS—An engine using the una-flow principle of central piston-controlled exhaust ports, but having an auxiliary single-beat poppet exhaust valve about midway between the end and the middle of the cylinder to avoid excessive compression when the engine runs noncondensing. The auxiliary valve cuts in automatically if the vacuum is lost and ceases operating when it is restored. Steam rates of 16.78 lb. with moderate superheat and 19.16 lb. with dry-saturated steam noncondensing are claimed.

The una-flow engine has been in use in Europe for several years, and the economy obtained by it, together with its simplicity, has led to its rapid adoption abroad. The principle involved has for its object the elimination of one of the greatest losses in reciprocating steam engines.

With the una-flow engine, the steam enters the cylinder at the ends, after passing through steam-jacketed heads; and, after cutoff and expansion have taken place, it is exhausted through ports arranged around the center of the cylinder, which are uncovered by the piston at the end of the stroke. The steam has, consequently, a flow in but one direction—hence the phrase "uni-directional flow," of which "una-flow" is a derivative.

In the counterflow engine the steam returns on its path at the end of the stroke and is exhausted at the same end of the cylinder at which it entered. By this method, the cold expanded steam of considerable volume washes the cylinder walls and head during fifty to seventy-five per cent. of the return stroke, thereby cooling them to such an extent that the high-pressure steam, when it is again admitted, is cooled or condensed by coming in contact with the head and clearance spaces of the cylinder which have just been cooled by the expanded exhaust steam.

It is this cooling effect that causes what is termed "initial condensation" which is largely eliminated in the una-flow engine, where the ends are kept hot and the center or exhaust belt cool.

It was to remedy this fundamental defect of the counterflow engine that successive expansion stages were resorted to, as in compound or triple-expansion engines. Superheating has also been employed, but it cannot be effected without some cost in installation and operation and it does not entirely remove the difficulty.

By avoiding the cooling of the clearance surfaces in the design of the cylinder itself, it is possible to obtain in a single cylinder as many expansions, with as good or better economy, as can be obtained in a compound or triple-expansion engine; and the practical advantages of the simpler valve gear, the smaller amount of cylinder and gear lubrication required and the higher mechanical efficiency will appeal to all engineers.

In the una-flow engine as ordinarily built, compression begins as soon as the piston covers the central exhaust ports and continues during some ninety per cent. of the stroke, which, even with small clearances, does not cause it to mount above the initial pressure so long as the engine is operated condensing, with a fairly good vacuum, as is the almost universal practice in Europe.

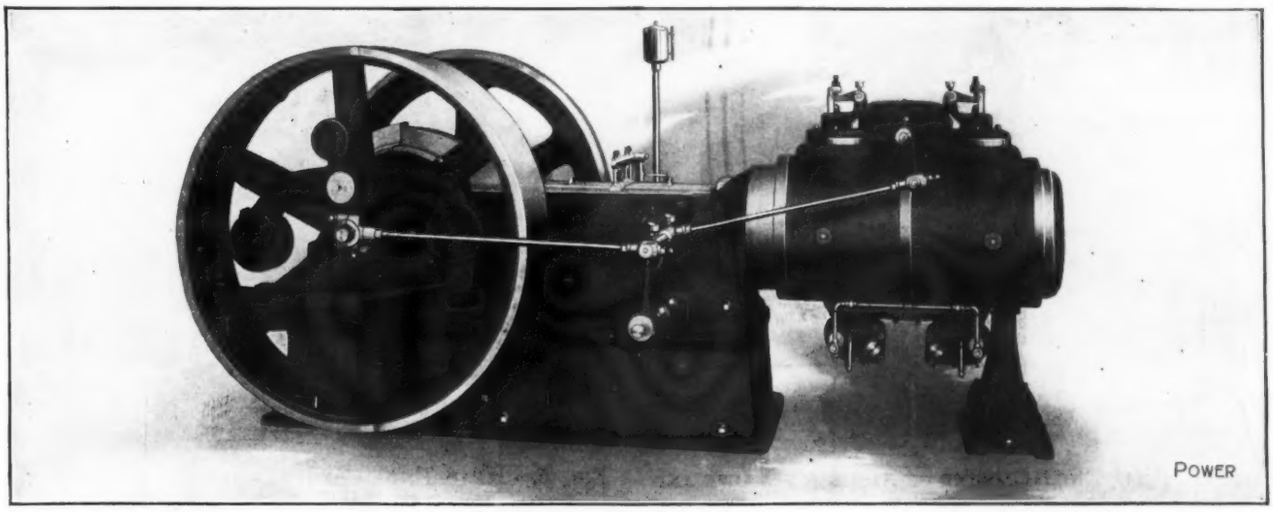


FIG. 1. THE UNIVERSAL UNAFLOW ENGINE

If the engine should be operated noncondensing, however, the compression, starting almost at the beginning of the return stroke and with atmospheric pressure instead of vacuum in the cylinder, would become so excessive as to be detrimental to the engine unless large clearances were provided.

In America, where some ninety per cent. of the steam engines installed operate noncondensing, modification was necessary to meet this condition, and the engine under review, and shown in Fig. 1, was designed by L. G. Skinner, of the Skinner Engine Co., Erie, Penn., for this purpose. Its essential feature is an auxiliary exhaust valve at that point in the cylinder where it is usual to start compression in a counterflow engine.

The una-flow principle is not sacrificed nor its effect vitiated, as the volume of expanded steam ready for exhaust is still emptied from the cylinder through the central exhaust ports, and only the vapor at atmospheric pressure remaining in the cylinder between the central exhaust ports and the auxiliary ports is removed through those ports instead of being compressed into a large clearance.

The valves are not placed at the ends of the cylinder,

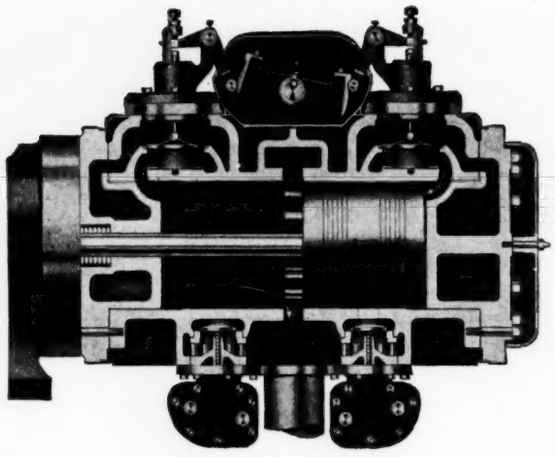


FIG. 2. HEAD END: ADMISSION ON DEAD CENTER. FRAME END: EXHAUST THROUGH CENTRAL PORTS

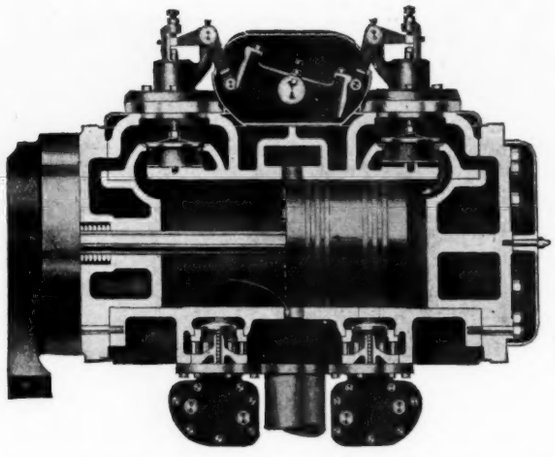


FIG. 3. HEAD END: FULL OPENING OF VALVE. FRAME END: EXHAUST THROUGH CENTRAL PORTS ABOUT TO CLOSE

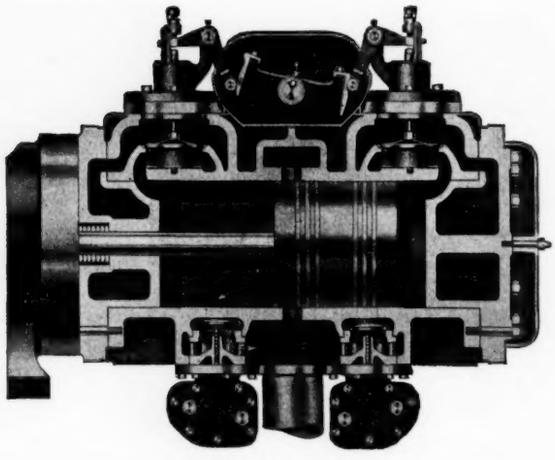


FIG. 4. HEAD END: CLOSING OF ADMISSION VALVE AND BEGINNING OF EXPANSION. FRAME END: DISPLACEMENT OF TRAPPED VAPOR THROUGH OPEN AUXILIARY EXHAUST VALVE

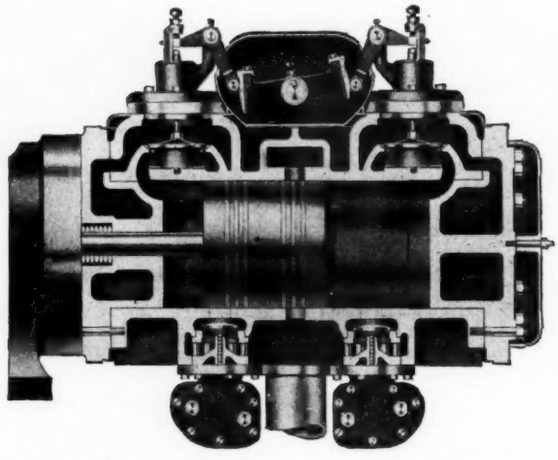


FIG. 5. HEAD END: CONTINUATION OF EXPANSION. FRAME END: COMMENCEMENT OF COMPRESSION BY PISTON COVERING AUXILIARY EXHAUST PORT

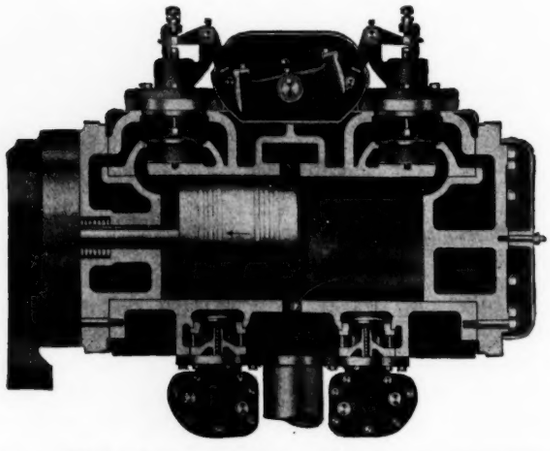


FIG. 6. HEAD END: BEGINNING OF EXHAUST THROUGH CENTRAL EXHAUST PORTS. FRAME END: CONTINUATION OF COMPRESSION

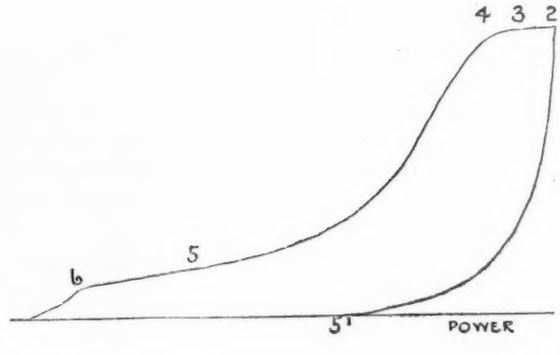


FIG. 7. THE NUMBERS CORRESPOND WITH THOSE OF THE SECTIONS SHOWING POSITIONS OF PISTON AND VALVES AT POINTS INDICATED

THE UNIVERSAL UNAFLOW ENGINE OPERATING NONCONDENSING

for this would cause the trapped steam to sweep the entire length of the cylinder and cool the hot ends with its washing effect.

That the una-flow principle is still effective with this arrangement is proved by the fact that the Universal Una-flow engine, according to the builders' statement, gives practically as good economy at one-fourth load as at full load, showing that the effects of cylinder condensation have been largely eliminated.

The action of the engine, operating noncondensing, is described in Figs. 2 to 6, while the numbers on the accompanying indicator diagram, Fig. 7, correspond to

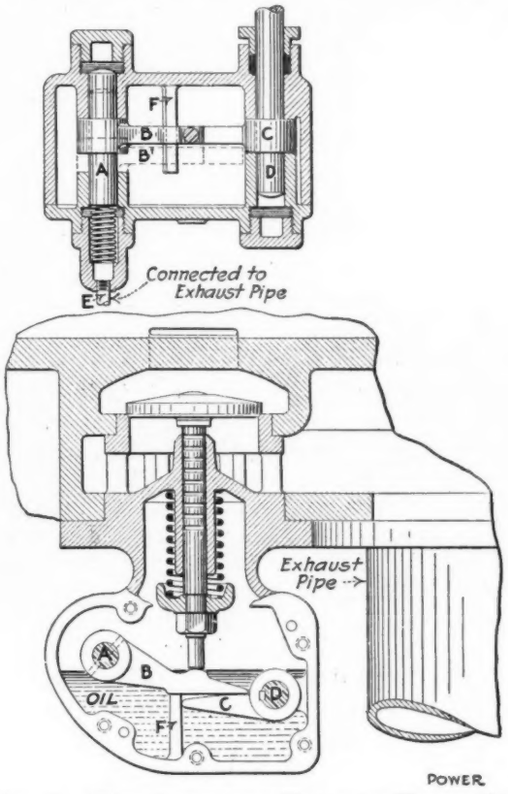


FIG. 8. THE AUXILIARY EXHAUST VALVE GEAR

the numbers of the sections and indicate the position of the head end of the piston in each one of these cuts except the 5', which refers to the condition in the frame end when the piston and valves are as shown in Fig. 5.

In Fig. 2, the engine is shown on the dead center, with admission taking place on the head end; and at the frame end, exhaust continuing through the central port. The auxiliary exhaust valve is still closed. In Fig. 3, just as the piston is about to cover the central exhaust ports, the auxiliary valve commences to open. Notice that this opening is accomplished when there is exhaust pressure on both sides of the valve, and the valve opens against no difference in pressure.

In Fig. 5, the piston has passed over the edge of the auxiliary port and compression has commenced, although the auxiliary valve is still open and does not close until the piston has nearly reached the end of its stroke. Hence, the valve closes with exhaust pressure on both sides and again against no difference in pressure. The fact that the auxiliary valve both opens and closes under balanced pressure permits the use of a single-seated poppet valve, which involves less clearance than a double-seated valve which the builders would have been forced to use if the valves were to open and close against pressure. The clearance of the single-seated valve is claimed by the builders to be less than one per cent. in most of the engines which they are building. It also allows the use of an extremely simple and compact driving gear free from excessive stresses. A spring of but small tension is required; in fact, the valve has been operated without any spring what-

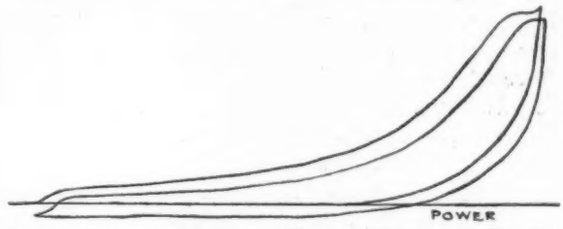


FIG. 9. CONDENSING AND NONCONDENSING DIAGRAMS TAKEN 10 SECONDS APART

ever. The spring is telescopically mounted upon the valve in order that the entire exhaust gear may be above the floor and accessible.

When operating condensing, the auxiliary exhaust valves are automatically disengaged and remain closed at all times unless the vacuum should break, whereupon the valves are automatically placed in operation and the engine becomes a noncondensing una-flow engine again.

Operating condensing, the Universal Unaflow has a steam rate comparable to that of the European una-flow engine, with the advantage that excessive compression is automatically prevented if the vacuum should fail. It is this feature of automatically accommodating itself to both condensing and noncondensing conditions which led the builders of this engine to name it the Universal Unaflow.

Fig. 8 shows the construction of the auxiliary exhaust valve gear. *A* is the shaft supporting the idler *B*, which is operated by the shear cam *C*. This cam is operated by the engine valve gear which is connected to the shaft *D* on the outside of the cam box.

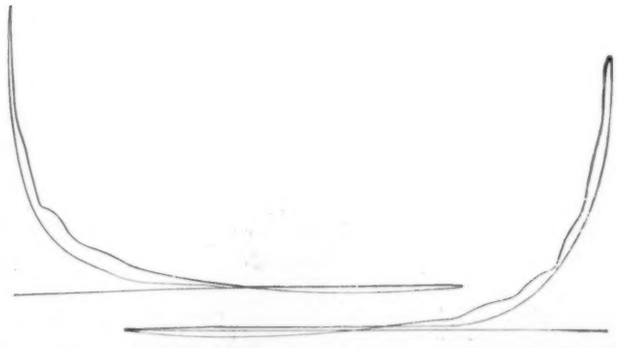


FIG. 10. FRICTION DIAGRAMS SHOWING 4.49 PER CENT. OF RATED LOAD

When the cam *C* raises the idler *B*, the latter raises the single-beat exhaust valve, the stem of which projects within a short distance of the idler *B*. The spring around the valve stem has only enough tension to insure quick closing when operating at high speeds. The shear cam is so designed that there is practically no sliding action on the idler. Both cam and idler are of steel and are immersed in oil.

The pocket *E* is connected to the central exhaust port by means of a small pipe, and the function of the spring in this pocket is to keep the idler, through its attached

shaft, in register with the stem of the valve and the cam C directly underneath.

When the vacuum reaches a predetermined point, it overcomes the tension of the spring in the pocket E and draws the shaft into the pocket. This in turn shifts the idler to the dotted position B' and out of register with the cam C, so that, while the cam still moves as before, it cannot lift the valve.

Therefore, the valve remains closed when there is a vacuum in the exhaust pipe, and is kept tightly closed by the force of the vacuum itself exerted on the under side of the valve. The pressure in the cylinder acting on top of the valve also tends to keep it closed.

The bridge F acts as a slide and a rest for the idler and holds it at the proper height so that if the vacuum should fail, the spring now asserting its force in pocket E would slide the idler between the cam and valve stem, whereupon the auxiliarv exhaust automatically begins its functions.

The indicator diagrams reproduced in Fig. 9 were taken from a Universal Unaflow engine operating both condensing and noncondensing. They were taken about ten seconds apart—the time required to break the vacuum.

Operating condensing, it will be noticed that the compression begins at 10 per cent. of the return stroke, because the auxiliary exhaust valves are not in operation; and when operating noncondensing the compression has been delayed by the means just described.

Labyrinth or water-groove packing is used upon the auxiliary exhaust-valve stems. The admission valve gear is extremely simple, consisting of one rocker-shaft, with case-hardened steel cams operating in an oil bath, and controlling the operation of the valve by means of forked levers on which are mounted rollers bearing against the cams.

Double-beat poppet valves adapted to steam of high and low pressure, saturated and superheated, are employed. Instead of mounting the spring above the valve, as is customary, it is telescoped in the housing, but, of course, not in the steam space. All adjustments of the valve, cams and rollers are made by one setscrew located above the lifters.

It was the builders' motive to design a valve gear capable of operation at high speeds. This involved simplicity, and there are but twelve joints in the combined admission and auxiliary exhaust gear.

The first engine with this gear was operated, off and on, for nearly a year in the builders' shops, at a speed of 275 r.p.m. It was then placed in service, and has now been in operation nearly two years on a night-and-day schedule, at a speed of 257 r.p.m. without repairs or renewals.

The mechanical efficiency of the engine is remarkably high. Fig. 10 shows friction diagrams taken from the 160-hp. engine illustrated in Fig. 1, operating at 232 r.p.m. The indicated horsepower was 7.19, showing a friction loss of 4.49 per cent.

A recent test of a 400-hp. engine showed a friction loss of only 9.06 i.hp., which is equivalent to a mechanical efficiency of 97.735 per cent.

The economy of this engine when operating condensing is said to be about the same as that of the European engine, while the builders claim a remarkably flat curve for it when operating noncondensing. Tests with saturated steam at 126 lb. pressure have shown a water rate as low as 19.16 lb. per indicated horsepower-hour at one-half load.

With steam at 159 lb. pressure, superheated 93 deg. F., a 13x16-in. engine operating noncondensing, when tested by the purchaser's consulting engineer, gave a steam rate of 16.78 lb. per i.hp.-hr. at one and one-fourth load, and 17.3 lb. at one-fourth load, showing a practically flat curve throughout the load range.

All of these tests were made without any special preparation of the engine, one test having been made within seven hours of the time the steam and exhaust pipes had been connected to the engine on the builders' test block.

Several thousand horsepower of these engines are now in active service—a few on night-and-day schedules. They are built in center-crank and side-crank types, in sizes ranging from 150 to 750 hp. The Skinner governor, automatic oiling system and general design of bed and parts are used.

Heating and Ventilating a Dye Shop

By H. M. Nichols

The problem of properly heating and ventilating a dye shop during the winter months presents unusual difficulties, and as a consequence the atmosphere of many dye rooms in otherwise well regulated plants is damp and icy and filled with vapor during the winter months. Under this condition, it is not surprising that the efficiency of these departments falls off materially.

It was the writer's good fortune to be well acquainted with a plant in which this vexing problem had been so successfully solved that this department was as well heated and ventilated throughout the entire year as any department in the plant.

As is well known to those familiar with dye-house ventilation, the greatest trouble arises from the condensation of the vapor which is continually rising in great clouds from the dye kettles and tubs. When the steam comes in contact with the cold air which is flowing in from the doors, windows, etc., it condenses, rapidly sinking toward the floor and thus obscures the view.

In the establishment referred to, this difficulty was overcome by the installation of a double fan system. One fan was put in to blow heated air along the floor line, while another was employed as an exhauster near the roof to discharge out of doors. With this combination, the escaping steam was caught by the up draft of the incoming heated air and carried above the heads of the workmen, where it was caught up by the suction of an exhaust fan. The hot air was taken from the boiler room through a conduit to the dye shop at a nominal cost for operation beyond the power necessary to drive the two fans. In most plants, however, it would probably be necessary to heat the air by means of a steam coil.

Copper-Steel—The use of about ⅛ of 1 per cent. of copper in steel greatly increases its resistance to corrosion in acid. That it makes it a better material for use under general conditions and better able to resist the natural corrosion from exposure to the weather, has yet to be demonstrated.

Application for New Jersey licenses—Engineers and firemen of New Jersey should immediately request applications for licenses if they wish to obtain them without examination. All applicants filing applications after Dec. 31 will be subject to examination. Watchmen who handle boilers carrying over 10-lb. pressure are obliged to have firemen's licenses.

Municipal Electric Works, Schaffhausen, Switzerland*

SYNOPSIS—Water which would run to waste during the night and Sundays is made to pump water from the tail race to an elevated reservoir, thus storing energy to meet the day demand. The plant has seen the development from rope to electric transmission and from an efficiency of 39 per cent. to creditable modern performance.

The article treats of the increase in capacity of a hydraulic power installation on the Rhine opposite the city of Schaffhausen, Switzerland. The installation in question existed some forty years ago as a plant of three hydraulic turbines utilizing the energy of an artificial head in the river; two of those turbines delivering their power across the river and for about 2000 ft. up-stream along its right bank through the medium of a, at that time notable, system of wire-rope transmission for the operation of various industries in that city, and the remaining turbine furnishing power through a diagonal line of shafting to a consumer at the top of the slope of the left bank of the river.

Under increasing load the multiplicity of bevel gears and shafts absorbed a very large share of the attendance and maintenance costs, representing as well an important power loss, and as this first installation, Station A, was no longer able to meet the demands on it for power, the water-works company in the years from 1887 to 1890 erected the lower plant, Station B, equipped with five Jonval turbines of 300 hp. each at 48 r.p.m., and, like the other turbines, fitted for rope drive. Even at that time two of these five turbines were used for electric-power transmission as they operated two rope-driven, direct-current generators for delivery of their energy through an overhead line to a spinning mill some 2200 ft. distant, and the second step toward electrification was made when the city of Schaffhausen leased two of the remaining turbines for the operation of alternating-current machines to supply the city lighting and street-railway systems, while in 1900 new turbines of 350 hp. each and, as in Station B, with bevel-gear-driven, three-phase current generators, displaced the old rope drive in Station A.

Intake and other conditions resulted in perceptible head losses which, taken in conjunction with the faulty suction effect of the cylindrical housing of the turbines, reduced the efficiency of Station B to 39 per cent. Improvements resulted in raising the turbine efficiency alone by about 60 per cent., of which, however, 11 per cent. at low water and even 19 per cent. at high water, disappeared again in the form of head losses, so that only through a complete rebuilding of the station could it have yielded a service commensurate with the available water and the conditions of head. Such a rebuilding received the sanction of the city authorities in 1905 and 1906 in that they decided on redesigning Station B on an equipment basis of five 550-hp. turbines, including one reserve unit, and to erect Station C on the right bank of the river with a view to securing throughout the night hours the energy of a volume of water up to then unutilizable. This last mentioned station contains electrically driven pumps operated by current generated in Station B and delivering their water at night into a high-level storage reservoir to be drawn thence by day for conversion into electric current by means of high-pressure turbines and generators. Station C is designed for the reception of four 1000-hp. units, of which two were put in service in 1909.

The fall at the locality in question varies from, say 12.13 ft. at high water to about 15.74 ft. at low water. The early turbine installation of Station B, at the conceded minimum water volume of 1400 cu.ft. per second, yielded under the most favorable conditions of fall a maximum of about 1200 hp., measured at the turbine shaft. In consequence of the unfavorable intake conditions, such as a contraction of its cross-section and two right-angle bends, added to the hindering effect of the two-part gates for shutting off the turbine chambers, the hydraulic efficiency of the plant was seriously reduced as, on a basis of 1400 cu.ft. of water per second with the referred to fall of 15.74 ft., using modern turbines and eliminating the mentioned head losses, it is possible to develop 2000 hp. It was, therefore, decided to install five turbines of a normal 550 hp. capacity each in place of the former 300-hp. units, one to act as a reserve, and to improve the intake so far as permitted by local conditions. The intake grating was placed ahead of the gates and its flow cross-section materially increased. To utilize to the best advantage the flow velocity of the water in the intake channel, and as far as possible to use the present turbine chambers, these latter were built of spiral form whence the former swirling action and whirlpool effect were much lessened, the water delivery made more favorable in spite of the relatively small channel and a more rational use of the fall permitted.

The duplex Francis turbine adopted utilizes the conditions of head to a degree which it would have been impossible to attain with the simple turbine.

The surplus power development of the low-pressure Station B, available during nights and Sundays, determined the capacity of the high-pressure storage installation, as may be seen from the following: Of the present duty of about 3050 hp. available from the two stations on the left bank of the river there are used during nights and Sundays for light and power approximately 550 hp., leaving for pumping purposes 2500 hydraulic hp. for Stations A and B, or, say 2000 electrical hp. at the motor shafts of Station C. With this power 88,250 cu.ft. per hour can be delivered into the high-level reservoir, so that to fill it requires 30 hours; a length of time readily available between Saturday evening and Monday morning.

From the foregoing the following water values are obtained as of the storage system:

	Cu.Ft.
Reservoir storage capacity	2,647,500
Less for losses and reserve	176,500
Leaving normally on hand	2,471,000
Pump delivery during five week-day nights	5,295,000
Thus affording for six days	7,766,000
Or for one working day	1,294,300
Using for the maximum lighting load of 1000 hp. during 12 hours	465,960
There remains for power purposes	828,340

*Translated in abstract by William F. Monaghan from a reprint pamphlet of a contribution by Ing. H. Geiser to "Schweizerischen Bauzeitung," Vol. LIV., No. 25, 1910.

This amount of water suffices for 9800 hp.-hr. per day, or 980 hp. for 10 hours.

As for Stations A and B, the water for the operation of Station C is taken from above the dam, but unlike them Station C does not return its tail water to the same source, and hence, in effect, does not draw energy from the Rhine. This, at first sight, seeming paradox is explained by the before mentioned utilization of surplus power for the high-level storage of water afterward used to energize the station and then so discharged as to still be available for another local concession, a water right which had to be considered not in any further power development but during the rebuilding which was done. This arrangement permitted the supply for the storage reservoir to be pumped from the sluice way leading to the other concession, and at such hours and over such period that the amount at any time did not infringe on other local water rights.

The installation is interesting as an example of the conversion into useful effect of previously unutilized energy.

Will Quizz, Jr.

SYNOPSIS—Will Quizz, Jr., does not see how the barometer gets in on all tests of condensing plants or why it need be consulted in the case. Chief Teller makes it look like an ordinary vacuum gage.

"Tell me, Chief, what is a barometer, and how does it get into every statement of conditions of tests of condensing engines?"

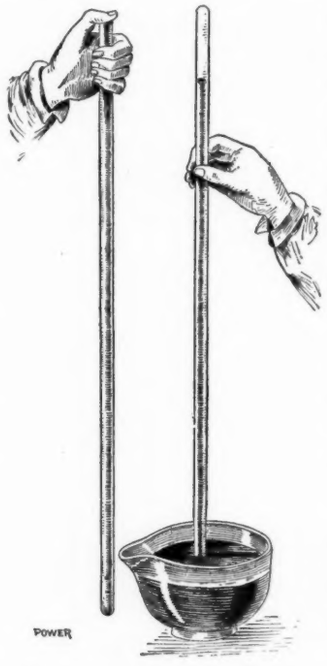
"Barometer, my boy? Just another name for vacuum gage—it's made up of two words meaning 'weight' and 'a measure.' If you operated an engine against a back pressure above the atmosphere, Will, you would use a steam gage to indicate it. If below the atmosphere, a similar gage, slightly modified, will answer for ordinary purposes. But for greater accuracy and finer graduation, it is necessary to use a gage more sensitive.

"I'm going to give you a brief history of the barometer; it will help you to get the idea clearly, and it also is a reminder of what was accomplished by some of the old-timers as compared to some of us who think ourselves *it*. Torricelli invented the barometer in 1643. He used a glass tube about 33 in. long, and closed at one end. He completely filled it with mercury, then put his thumb over the open end and inverted the tube in a cup of mercury. When he removed his thumb, the mercury dropped from the upper end for some distance, but remained at about 30 in. above the level of the mercury in the cup. There could be no air in the tube above the mercury, because it had been filled and none could reach the space through the mercury after the tube was inverted.

"This proved that there was pressure on the surface of the mercury in the cup sufficient to support the column of mercury 30 in. high in the tube, on the surface of which there was no pressure. It was then a simple matter to ascertain the weight of such a column of any height having an area equal to one square inch in section, by filling a tube and weighing it. It was found that 30 in. weighed 14.7 lb. This, of course, is atmospheric pressure. In this manner Torricelli established and proved that air had weight and thereby exercised a pressure on everything surrounded by it, and that its pressure varied according to its density and the elevation. At sea level it is spoken of as a 30-in. pressure, but if the air is filled with water vapor, which is lighter than dry air, the barometer is said to 'fall.'

"The effect of elevation was tested soon after Torricelli's discovery by a Frenchman named Pascal, who carried a barometer to the top of a mountain and found that the mercury in the tube fell several inches.

"The barometers used by mountain climbers, air navigators, and others, to tell how high they are above sea level do not as a rule contain mercury; these barometers are simple sensitive pressure gages. Their construction is also interesting and instructive, and I suggest you look up the whole subject at your leisure."



TORRICELLI'S BAROMETER

"Now, tell me, Chief, how is this applied to the condenser? I know by connecting the upper end of a glass tube (by a rubber tube) to the vacuum system and having the lower end immersed in a vessel containing mercury, that the tube will be partly filled with mercury, and that the inches of vacuum may be measured with a rule, above the level in the containing vessel, but how does it figure in tests of condensing engines?"

"Just this, Will; after the test you spoke of you should try the other simple test and find out what it was possible to get under the atmospheric condition. In that way, you would determine the behavior (or efficiency) of your condensing equipment and the back pressure the engine had to work against at that particular time.

"This air pressure constitutes a back pressure directly against a non-condensing engine but the slight difference in the barometric reading from day to day is such a small percentage of the total back pressure that it is not often taken into account with such an engine. With the condensing engine, however, the same difference would be a large percentage of the total back pressure. Each inch of mercury is equal to approximately one-half pound. To be exact, multiply the height in inches by 0.491, which, you see, is 0.009 less than one-half, but for practical purposes one-half is close enough. The difference between 28.5 in. and 30 in. would mean nearly three-quarters of a pound difference in the back pressure.

"All of this goes to show that for comparison and tests it is necessary to consider the barometric readings."

Editorials

Testing Out Automatic Safety Devices

If an engineer is operating a power plant equipped with safety devices, it is reasonable to assume that a certain amount of reliance will be placed upon their automatic operation. As a matter of fact, such devices are so common in power plants that it becomes natural to assume that, because they are designed to act automatically, they will always do so.

This assumption really invites accident, not because of any fault in the design or intent of the device, but because a certain condition or conditions can arise which will cause the device to become inoperative.

If a man breaks an arm it is impossible to use it freely when the splints have been removed, and it is only by exercising the muscles that the free use of the member is regained. There are certain members of safety devices that require frequent use to keep them in condition. If they fall into disuse, the operating parts become stiff in action, and there is danger that they will fail to operate when it is imperative that protection be afforded.

For instance, an engineer upon taking over a steam plant tested the safety device on the throttling governor of a small slide-valve engine, but it did not work. It had been so long since the device had operated that the movable parts were coated and caked with oil and dirt. If the engineer had not been at hand to close the throttle, in case of a runaway the engine would have been wrecked.

Had the governor belt broken during a day's run, when no one was near to close the throttle, the chances are that the real cause of the wreck would have remained a mystery.

He is a wise engineer who will use those safety devices which lend themselves to hand as well as to automatic control in handling the machinery which they should safeguard. Steam turbines are equipped with automatic-control throttle valves designed to shut off the steam in case of excessive speed. These valves can be tripped by hand, and the engineer who stops a turbine by tripping the valve has the assurance that it is in working condition.

Most engineers use the automatic valve in shutting down a unit, as they realize the importance of positive operation. If an automatic safety throttle valve is never operated until there is an emergency call, in all probability it will fail to work.

Not long ago a large steam turbine was wrecked because the automatic throttle valve failed to work. Its design was that of hundreds of other successful valves, but it was not used in shutting down the unit—in fact, it had not operated for weeks. In consequence, the valve-stem packing had so hardened and stuck that when the call for automatic safety protection came, the failure of the valve wrought disaster.

Testing out such a device is small enough in itself and takes little time, but it will probably prevent wrecking an expensive machine and seriously crippling the service.

Exit the Politician--Enter the Engineer

Engineers of all kinds will be interested in the advent of more efficient methods of municipal administration, as outlined by Henry M. Waite, city manager of Dayton, Ohio, at a recent joint meeting of engineers in Boston. Eleven months' trial of this plan of government on the largest scale thus far attempted in this country gives ample evidence that by its means a city of one hundred and twenty-five thousand people can be run on a strictly business basis, free from political interference, open to the fullest publicity, and with concentrated responsibility in the direction of every branch of the municipal service. Without discussing the merits of the city-manager plan as compared with a straight commission or the Federal form of government, it is desirable to realize the meaning of this advanced movement for the engineering profession, for more will be heard of this matter in the near future.

Fundamentally, the larger problems of city administration are closely related to engineering. Water-supply, sanitation, relations with public utilities, the conduct of municipal electric service, the scientific management of pumping plants, highway construction and maintenance, motor transportation, fire protection—these and many other issues either demand engineering advice for their proper solution or call for technical insight in their administration. More and more executive duties are being laid upon the capable shoulders of men of engineering training in connection with public affairs, and just as the great railroad systems and innumerable industrial organizations are putting engineers into the chairs of manager and superintendent, so communities with far-sighted appreciation of the analytical and constructive abilities of technical men are turning to them for help in the search for more efficient city management. The opportunity before engineers qualified to enter this field is one of the most notable that has ever presented itself to the profession.

To make a success of this work the engineer must take himself in hand and get entirely out of narrow ways of thinking and acting. In his address at Boston, Mr. Waite put special emphasis upon the importance of the engineer acquiring the ability to talk on his feet before those whom he wishes to persuade that a certain program is advisable. It is not enough to be able to write a straightforward report on a proposition, but a man must be capable of putting his ideas into words under the fire of hostile questions, and of thinking and speaking clearly under the most trying conditions. Lacking a sense of humor which can appreciate a situation without the slightest abatement in courtesy, the engineer who would enter this field had better give up the idea. In the past, probably seventy-five per cent. of the problems "put up to" the engineer have led him to go off somewhere by himself and work out a solution. This tends toward inbreeding,

which, if carried to extremes, is fatal to executive direction or leadership.

The ability to look at problems in a large way, to cultivate the controlled imagination and to reason out the probable consequences of various policies and steps ought not to be difficult to the engineer, whose experience so generally calls for such qualifications, although often in a very limited field. A knowledge of materials and their strength, a thorough comprehension of the principles of mechanics, steam engineering, electricity, hydraulics, machine design, applied mathematics, and physical science as a whole will help in the administration of city affairs in many cases quite as much as being well posted in legal matters, and perhaps even more than the ability to round up votes in a given district at election time. The variety of problems which come before a city executive of the manager type is almost beyond belief; but the fitness of a man with engineering training, plus common sense and the ability to get along well with his fellows, for dealing with questions far removed from those of technical practice is being demonstrated daily.

It is only a few weeks since a great Boston charitable organization retained a consulting engineer to investigate its efficiency as a philanthropic instrument, and the resulting report, which the engineer donated out of personal interest in the work, shows that it is not only in the field of iron and steel and steam that modern engineering is enlarging its usefulness to the world.

There is a lesson for every engineer, however humble and far removed he may be from public affairs, in the broadening call upon the great profession of which he is a part for larger services to civilization, and as surely as "he that ruleth his own spirit is greater than he that taketh a city," so surely will these higher conceptions of engineering responsibility and development benefit the individual as well as the community which takes the long look ahead.

Our Careless Shippers

Notwithstanding all that has been said by our consuls and business agents in South American countries, our manufacturers and jobbers continue to ship their goods crated. The foreign shipper packs his wares in boxes. This carelessness must be corrected if we would hold the trade we already have in these countries, let alone extend it.

There are few harbor and docking facilities in these countries to the south of us, and this want makes it necessary for steamships to unload their goods by transferring them to lighters, and usually in heavy seas.

American houses use one- and one-and-a-quarter-inch material. Foreign shippers use two- and two-and-a-half-inch lumber, reinforcing the boxes with heavy cross-braces, screwed in, the whole being protected by bands of sheet iron placed on the exposed edges.

Our Minister to Ecuador, Charles S. Hartman, vouches for two flagrant instances of careless packing of goods shipped to Quito. First, the Quito Electric Light & Power Co. bought seven motors from one of the largest electrical manufacturers in this country. The damaged motors arrived absolutely bare of any protecting material. Second, a large consignment of machinery arrived in flimsy crates and broken in nine places. As the broken parts cannot be made in Quito, the machinery is useless and the shipper has lost a valuable customer.

Our business houses should, at the least, imitate the foreign shipper in the matter of packing goods, and we see no good reason why they cannot excel him. "This fault," says our Callao correspondent, "lies with the large as well as the small shipper. It is a wonder to me that we have any trade here at all."

That the state of war in Europe has opened to us an immense opportunity to increase our trade with our South American neighbors is undeniable. Are we to defeat the huge efforts for extended trade being made by our commercial agents, business associations and railroad and steamship companies by an inexcusable carelessless that will become criminal if longer continued?

The market has been created: let us meet the moderate requirements.

Getting a New Jersey License

There seems to be much misunderstanding by engineers and firemen in New Jersey as to how to get licenses under the new law of that state.

If a license is desired without having to take an examination to get it, the engineer or fireman has simply to request an application from the Commissioner of Labor, at Trenton, fill it out and have it filed on or before December thirty-first. It costs nothing to ask for the application, but the applicant is required to send two dollars with the application when it is returned to the Commissioner's office. One does not have to be a citizen to get a license.

All engineers and firemen, as well as watchmen caring for boilers carrying over ten pounds pressure, are required to have licenses. An oiler does not need one.

We understand that, even though there is a licensed head fireman in charge of the boiler room, the fireman under him must also be licensed. It is the wish of the License Bureau that each men make his own request for an application.

A charge of twenty-five cents is made for the transfer of a license from one plant to another.

A fireman may change plants as much as he pleases and does not require an examination for each change.

For engineers there are twelve classifications, and should a man change to a plant of a different class, as from a mill to a hotel plant, he must, according to the ruling of the Bureau, take another examination, for which, we understand, he pays twenty-five cents.

A man may work in a plant for thirty days without a license. No first-class unlimited licenses are being issued. The understanding is that licenses must be renewed every year at a cost not to exceed two dollars a year for renewal.

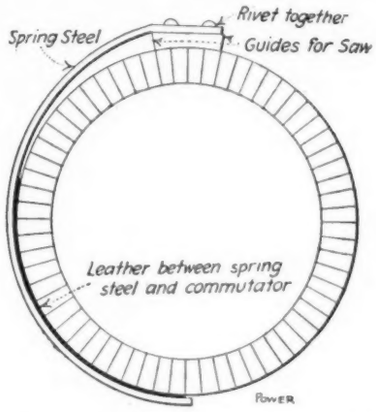
The explosion of the boiler at the Continental Hotel in New York City is another demonstration of the fact that in spite of all that has been said of their unaided holding power, boiler tubes ought to be flared or beaded over.

This week's cartoon made such an impression on one of our editors that he "orderfied" his desk, which goes to show that we know how to "take our own medicine" and "practice what we preach."

Correspondence

Guide for Undercutting Mica

The sketch shows a spring guide for the saw blade in undercutting mica on commutators. We have found



GUIDE FOR SAW IN UNDERCUTTING MICA

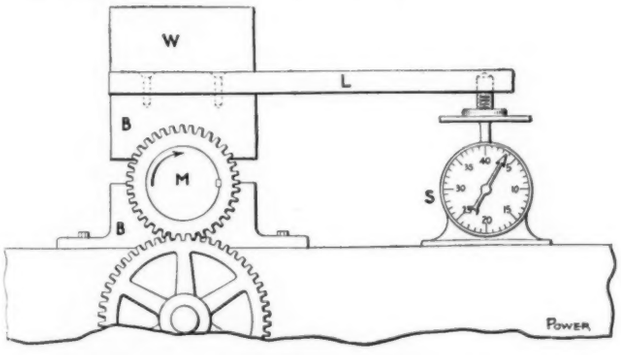
this very satisfactory and trust that it will appeal to other readers.

WILLIAM WAYNE.

Chisholm, Minn.

Testing the Value of Lubricants

The best way to determine the value of one lubricant as compared with others for the same bearing is to give it a practical test. I have constructed a machine for the purpose which will easily and quickly show which of a num-



MACHINE FOR TESTING LUBRICANTS

ber of lubricants will eliminate the most friction in a bearing.

The testing machine is composed of two brasses *B*, a pin *M* keyed to a driving gearing, a suitable lever *L*, a weight *W* and a spring scale *S*.

The brasses *B* may have brass or babbitted bearing surface, depending on which type is used in the plant. The weight *W* should be heavy enough to produce the same pressure per square inch on the bearing as there is on the average bearings in the plant.

When the machine is idle, only a slight pressure will be registered on the scale *S*, but when the pin *M* is rotated in the direction of the arrow, the pressure on the scale will increase directly as the friction in the bearing; in other words, the better the lubricant, the less will be the pressure exerted on the scale.

Before testing a given oil or grease, the bearing surfaces should be cleaned thoroughly and covered with a coat of the oil or grease to be tested. The lubricant should be fed in at a part of the bearing having the least pressure—i.e., between the brasses.

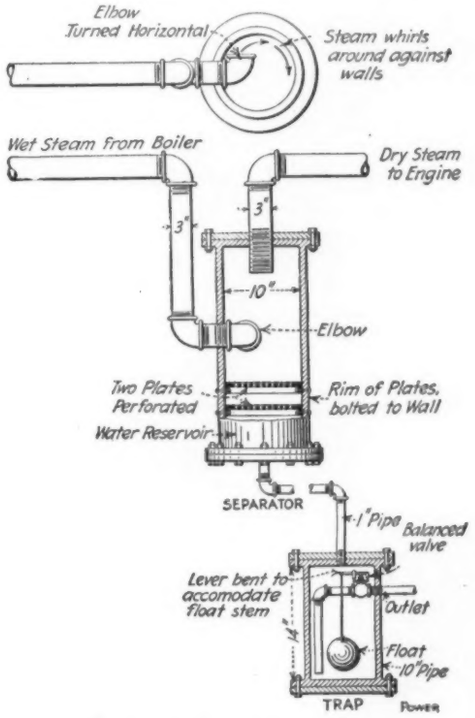
The pin *M* should be given a peripheral speed equal to that of the pins in use. A small motor which will give uniform speed makes a good drive. It is essential to feed the oil at a uniform rate and to note the average pressure on the scale; also to note the temperature of the bearing as well as that of the surrounding air for comparison in future tests.

SAMUEL L. ROBINSON.

Bar Harbor, Me.

Home-Made Trap and Separator

The accompanying illustration is explanatory of my home-made separators; they insure dry steam because



STEAM SEPARATOR AND TRAP

they are large enough to take care of sudden priming. Steam always passes through slowly as the ports are several times the size of the pipe. Maximum efficiency is

obtained since the efficiency is increased as the velocity of the steam is decreased.

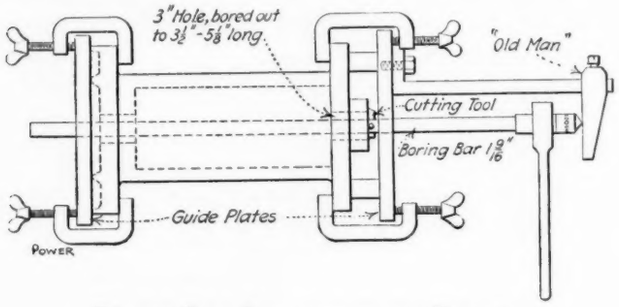
Centrifugal force projects the water against the walls, to which it adheres in the form of a rapidly rotating sheet, and flows continuously to the bottom of the reservoir. Once separated, under no circumstances can the water be again picked up by the steam current.

LUKE MARIER.

Fall River, Mass.

Bushing a Cable Drum

The illustration represents a cable drum which runs on a 3-in. shaft. It was badly worn and had to be bored out and bushed on a mountain, where transportation would have been costly if the work had been sent to town.



BORING-BAR OPERATED WITH RATCHET

The following rig was used: Four clamps, two guide plates, a boring bar $1\frac{9}{16}$ in. in diameter, an ordinary ratchet with Morse taper, and an "old man." All these parts were found at the camp. The bushings were ordered from town finished to size.

J. C. MATTISON.

Vancouver, B. C.

Expensive Cheap Firemen

The expensiveness of cheap firemen should be given more consideration by operating engineers and owners.

Some time ago I took a position as engineer and fireman in a sawmill in the South. The power plant consisted of two return-tubular boilers and an 18x16-in. slide-valve engine. The boilers were fed by an injector. I started on Thursday and quit on Sunday as the plant was in about the worst condition I ever saw. When I started to wash out a boiler on Sunday morning, I discovered that there were no blowoff valves; in their stead, plugs were screwed into couplings. The safety valve was on the main steam line and only one of the boilers had a stop valve. When I spoke to the owner about the blowoff valves, he said that they only cleaned their boilers twice a year (spring and fall); that they did not need any valves.

On Monday they started up with one of the handy men from the mill as engineer. I met him a few days later and asked him what the trouble was. "We had an accident," he said; "the boilers got full of water, and when the boss tried to blow them down they took him to the hospital." The owner lost the use of his left arm and the young fellow his job, simply because both were ignorant of the true condition and danger of these boilers.

On the other hand, you step into an engine room and find the equipment uptodate in every respect, everything polished to the limit and an imposing array of recording instruments on the wall—and the engine is making more noise than a trip hammer. In the boiler room you will find the firemen shoveling coal regardless of expense. Then you begin to wonder. The engineer tells you that his compound Corliss always was a steam eater.

The boss enters, looks at all the instruments and the coal chart, and then says to the engineer, "What do you fellows do with all that coal? Jim Jones did not use half as much as you fellows do. If this thing keeps up we will all be in the poor house pretty soon."

The boss has considerable money invested in this plant, but when Jim Jones wanted a raise in salary, the boss said he could not afford it as "business is poor this time of the year." So Jim quit and a cheaper man was put in his place with the results noted.

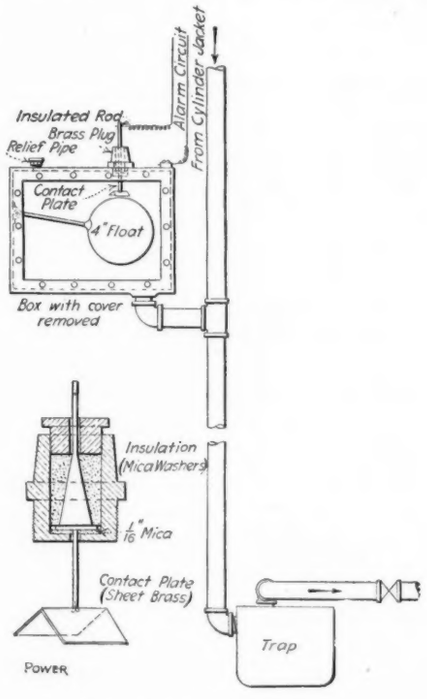
This actually happened in a plant in the Middle West containing a 3500-hp., cross-compound Corliss engine, and because they would not pay a real engineer $20 increase in salary per month they spent over $1200 more for fuel in less than seven months.

LOUIS B. CARL.

Marshfield, Wis.

Novel Trap Alarm

On our 1500-hp. cross-compound engine the steam supply line is drained through a bucket trap. It was thought advisable to safeguard the cylinder against any failure by rigging up an alarm to indicate the working of the trap. Our first alarm consisted in a trigger in connection with the bucket pivot which rang a bell every time the trap worked, but the ringing became one of the common noises of the engine room, and if it ceased was not noticed for some time. This proved that we needed an alarm that would indicate only if the trap failed to work.



ALARM ABOVE THE TRAP

We finally hit on the plan of letting the accumulation

of water set the alarm off. The illustration shows how this was accomplished. A cast-iron box containing a high-pressure float was attached to the drain line above the trap as shown. When water accumulates the top of the float will touch the contact plate, thus completing an electric circuit as one wire is attached to the cast-iron box and the other is insulated in the core of the brass plug. A small pipe was attached to the top of the box and to the steam line, thus equalizing the pressure and allowing the water to back up freely into the box. The cross-section of the plug shows its construction.

The alarm is tested at intervals by allowing the condensate to fill the box. Current from the generator with a resistance is used to ring the bell and also show a red light in a conspicuous place. This eliminates the uncertainty of batteries, as in the case of the first alarm we tried.

CHESTER W. WILSON.

Paterson, N. J.

Liner Put in Ammonia Cylinder

The ammonia cylinder of a compressor was so badly cut that it became necessary to bore it and insert a liner. The outside diameter of the liner was made equal to the inside diameter of the cylinder to obtain a close fit.

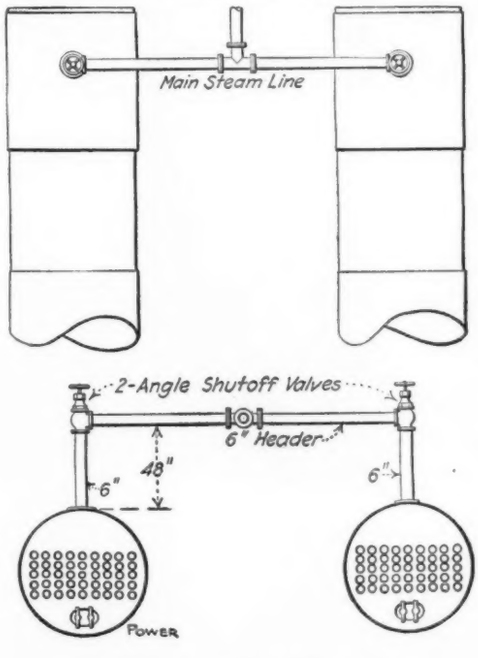
When all was ready the water jacket was filled and blow-torches were used to heat the cylinder until it expanded enough to allow the liner to be driven in by the aid of hammers and wooden blocks. It was necessary to use a hammer only for the last three or four inches. The compressor is now giving good service.

C. R. MCGAHEY.

Baltimore, Md.

Indiana Boiler Law

There has been much criticism of the Indiana boiler laws lately. While some of it is doubtless merited, the law as passed is undoubtedly a great improvement over no law. Regarding the header connections on p. 503, Oct. 6 issue, I have no doubt that they could be improved upon, but any of them would be a great improvement over the one in the illustration; this is the actual connection between two return-tubular boilers in an ice plant in northern Indiana and, of course, the inspector ordered it changed upon his first visit.



HEADER ORDERED CHANGED

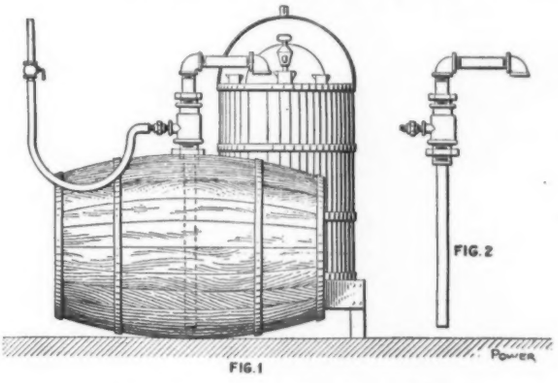
While there are many mistakes made by lawmakers, we should remember that it is far easier to see them then than in the making. Let us give credit for what has been accomplished.

E. F. GOAD.

Chicago Heights, Ill.

Emptying Oil Barrels

Oil may be discharged from a barrel into the supply tank or regular container by compressed air by the use of the following rig: Screw a nipple of a size corresponding to the hole in the barrel (say 1½ or 2 in.) into a reducing tee with a smaller pipe extending through both as shown in Fig. 1. The air supply is connected to the side opening of the tee.



AIR TO DISCHARGE THE OIL

The whole rig is shown assembled in Fig. 2 and can be easily understood. Care should be taken to avoid excessive pressure which may burst the barrel; a pressure gage is useful but not essential for this purpose.

LOUIS KREUTZKAMP.

Brooklyn, N. Y.

Boiler-Feed-Pump Trouble

At this plant, the water level is controlled by regulators while a pump governor on the steam line limits the pressure in the feed line.

One day the water-cylinder-head gasket failed, followed the next day by the one under the discharge-valve chamber. Little was thought of this until two or three gaskets would give out in one day. Either the pump was not rigid enough, the packing unfit or the pressure too high. Heavier covers were designed and put on and other packing tried, but without success. After three weeks it was accidentally discovered that the valve on the bypass around the pump governor was open about half-way. This allowed the pump to build up an excessive pressure in the feed line and caused the trouble.

A pressure gage was afterward connected. On again opening the bypass valve to see what the pressure would be, it went up to 250 lb., with 100-lb. steam pressure, limited only by the total water pressure on the plunger

equaling the total force of the steam. Had the steam cylinder been larger or the pressure higher, the water pressure would, of course, have been proportionately increased.

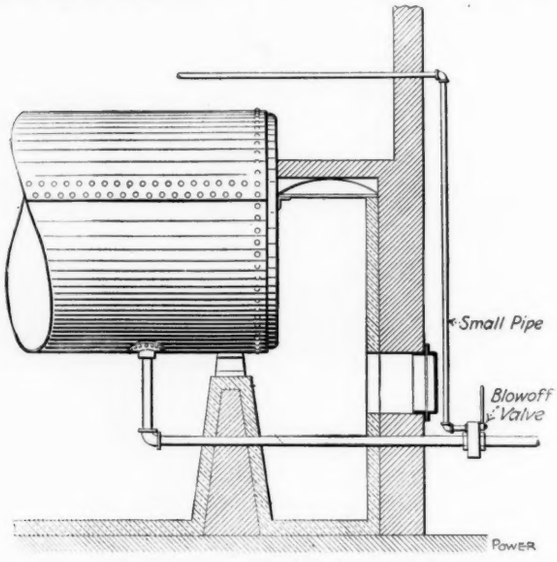
J. C. HAWKINS.

Hyattsville, Md.

Keeping Blowoff from Freezing

Last winter I had considerable difficulty in keeping the boiler blowoff valves from freezing; the pipes extended two feet outside of the boiler house. It had been customary to cover the pipes with waste, etc., and slip a barrel over them, but it was not easy to get at them to blow down.

I drilled and tapped the valves for ¼-in. pipe and ran a ½-in. pipe as shown in the illustration from a



CIRCULATING PIPE TO BLOWOFF

steam pipe and reduced it to ¼ in. at the valve. The steam condensing in the ½-in. pipe caused a slight flow of warm water back through the blowoff pipes, which kept them from freezing.

I know it costs something in coal, but it is cheaper than to have the valves burst. Of two valves which had been burst, I sent the casings to the city and had them welded by the autogenous process, so I now have two extras on hand to be used when needed.

ALBERT T. ROWE.

East Glastonbury, Conn.

Portable Power Plant

A great many boiler explosions annually occur in districts where portable boilers are in use, especially throughout the Southern states, where men who own sawmills take them where custom sawing is required.

One owner of a portable mill tried to "kill two birds with one stone" by acting as sawyer and engineer at the same time. He employed a boy to fire the boiler with wood waste from the mill, who knew nothing about the engine. One day the sawyer forgot all about the water in the boiler, and there was an explosion which destroyed the engine and seriously injured several people.

The most common safety devices are ignored, some boilers not having an ordinary gage-glass. A solitary gage-cock is occasionally blown; if it blows steam it is evidence that the water is getting low and more is added.

A high- and low-water alarm is seldom found on this kind of boiler, though it is easy to attach and might save many lives. Another simple safety device is the fusible plug, and boiler manufacturers often put them in whether specified or not.

The enactment of a uniform boiler inspection law is what is needed. Owners of larger plants usually have their boilers insured, which results in high-grade inspection. But the boilers in the small plants and portable boilers are not inspected, and they are often operated with defective tubes and without the ordinary safety devices.

As the insurance companies would decline to write such a risk as the average portable plant, their activity is not a complete safeguard. Let every engineer, boiler manufacturer and boiler user get busy in his own community and work for a compulsory inspection law.

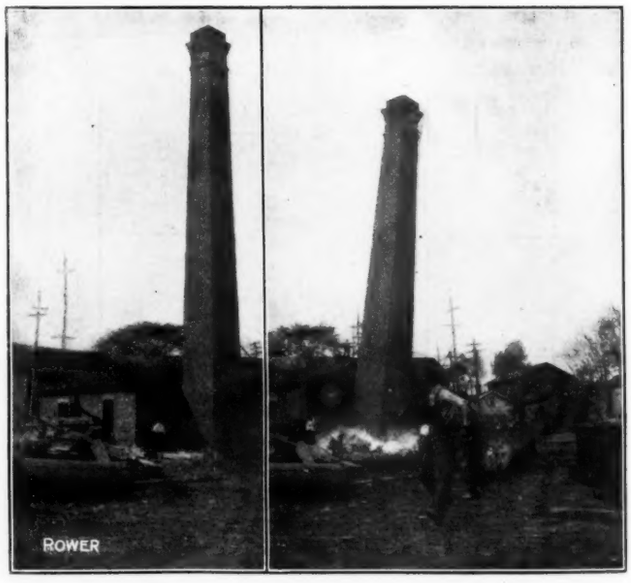
G. D. CRAIN, JR.

Louisville, Ky.

Removing a Brick Stack

It became necessary to remove a brick stack 80 ft. high by 9-ft. base at Waterloo, N. Y. The plan was to fell it, as one would a tree, by cutting away the two corners on one side, then driving 6x6 hemlock shores in each space, after which the remaining brickwork on that side was to be removed. Then the props were to be kicked out with a dynamite cartridge.

Just after 12 o'clock, Oct. 10, however, when all was ready, but before the button was pressed, the stack began to lean and crush the props. It went over about 15 or 20 deg., then collapsed, the inner lining of firebrick standing for a moment while the outer wall peeled off. Then all



ORIGINAL APPEARANCE AND VIEW JUST BEFORE COLLAPSING

collapsed within a radius of 25 ft. from the foundation. The dynamite did not explode, notwithstanding the débris falling on it.

Waterloo, N. Y. H. F. BREHM.

Inquiries of General Interest

Objection to Boiler Plate of High Tensile Strength—What is the objection to boiler plate having high tensile strength?

L. R. G.

Boiler iron or steel must have ductility even if tenacity is sacrificed. Beyond certain limits an increase of strength is usually accompanied by loss of ductility—i.e., the material is more brittle and is, therefore, more likely to fail from the bending action to which the plates of a boiler are subjected.

Inspecting Boiler Braces—How can it be determined whether the tie braces of a boiler are of proper lengths for taking up the stresses which they are intended to resist?

S. G.

By making an internal inspection of the boiler and ascertaining whether the braces are straight, have their ends properly shaped and secured to the shell and whether they give a clear sound when struck with a sharp blow of a hammer.

One Safety Valve to Blow Off Before the Other—Where two safety valves are used on a boiler, why is one set to blow at 90 lb. and the other at 95 lb. per sq.in.?

J. M.

One safety valve is set to blow off before the other to reduce the pressure more gradually and thereby prevent rupture of the boiler due to sudden changes of stresses of the boiler shell, and also to prevent lifting of water of the boiler from sudden reduction of steam pressure.

Advantages of Calcium Chloride Brine—What are the advantages of calcium chloride over sodium chloride (common salt) for brine used in refrigerating systems?

W. O. V.

One of the chief advantages is that the freezing point for strong solutions is much lower than for common salt brine. In double pipe systems it is better than common salt brine, for the latter may freeze and damage the cooler if the suction pressure is low. Another advantage is that calcium brine does not corrode metals as rapidly as common brine, but it is advisable to add about ½ per cent. of caustic soda to neutralize its corrosive action.

Steam in Return Lines of Vacuum Heating System—In a vacuum heating system equipped with automatic vacuum valves, how will steam get to the return lines and to the vacuum pump if the automatic valves are in working order?

L. P.

Although only water may be discharged from the radiators and drips, if the pressure in the returns or in the pump cylinder is lower than the pressure at which the water is discharged, then the condensate will vaporize until the temperature has been reduced to the boiling point corresponding to the pressure, and vapor thus formed is presented to the vacuum pump unless condensed by radiation of heat from the return lines.

Connecting Pumps with Common Suction and Discharge—When two or more pumps take suction from the same supply or discharge into the same service pipe, how should their connections be arranged for operating the pumps together?

K. W. A.

When the suctions are taken from the same tank, reservoir or pond, they should be sufficiently separated to prevent one pump from hindering the suction of another by the formation of currents or eddies. When the suctions are taken out of a common supply pipe the outlets from the pipe to the pumps should be Y branches of sizes which are in proportion to the rates of pump displacement.

For discharging into the same main the connections to the main should be by Y branches, or otherwise so arranged that the discharge from one pump will not be shut off by another, as by joining it at right angles or opposing its direction.

Adjusting Stroke of Duplex Pump—How can the stroke of a duplex pump be shortened or lengthened? R. E.

The stroke can be shortened by reducing the amount of "lost motion" between the steam valves and their stems. This can be effected by adjusting the position of the nuts on the valve stems for moving the steam valves. When each valve stem has a single nut between lugs on the steam valve the lost motion is reduced by using a thicker nut; or the stroke can be lengthened by increasing the amount of the lost motion—i.e., when there are two nuts and one lug to each steam valve by moving the nuts farther apart and where there is a single nut, the lost motion can be increased by making the nut thinner. Some pumps are provided with valves for regulating the amount of compression in the steam cylinder, thereby obtaining shorter stroke by increasing the compression or lengthening it by decreasing the compression.

Meaning, Use and Determination of "Horsepower Constant"—What is meant by the horsepower constant of an engine and how is it obtained and used?

W. E. T.

In figuring a number of indicator diagrams from one engine running at a constant speed, it is most convenient to compute first the horsepower developed per pound of mean effective pressure. This is called the "horsepower constant" and is to be multiplied by the mean effective pressure of each diagram to find the horsepower represented by that diagram.

As the value of the constant would be the number of horsepower which would be developed by 1 lb. mean effective pressure, therefore, as the usual formula is

$$\frac{\text{pressure} \times \text{area of piston} \times \text{piston speed in feet per min.}}{33{,}000} = \text{hp.},$$

or $\frac{PLAN}{33{,}000} = \text{hp.}$, then the formula for finding the horsepower constant is

$$\frac{1 \times \text{area of piston} \times \text{piston speed in ft. per min.}}{33{,}000},$$

or,

$$\frac{LAN}{33{,}000} = \text{hp. constant.}$$

Efficiency of Pressure-Reducing Valve—When steam is discharged through a pressure-reducing valve, is there a loss, and if not, what becomes of the heat which the steam may have contained before passing from the higher to the lower pressure?

J. M.

There is no loss in the sense of annihilation. Some of the heat contained in each pound (weight) of steam of the higher pressure passes off by radiation before reaching the valve aperture, and the heat which is employed for work in overcoming friction of the steam in its passage through the valve passes off by radiation or is conserved to the steam at the reduced pressure. But, with good insulation, the efficiency is nearly 100 per cent., for practically all the heat contained per pound of steam delivered to the valve is delivered to the low-pressure side, there to be absorbed by radiation, in raising the temperature or in evaporating water previously condensed, or in sustaining the temperature and pressure of steam on the low-pressure side, and any heat in excess of these demands will be employed as superheat—i.e., the steam at the reduced pressure will be at a higher temperature and will contain more B.t.u. per pound of weight than dry-saturated steam of the same pressure.

Figuring Cost per 1000 lb. of Steam—When the number of pounds of water evaporated per pound of coal from and at 212 deg. F., and the cost of coal per ton are given, what would be the short method of figuring the cost of coal required for evaporation of 1000 lb. of water from and at 212 deg. F.?

H. B.

One thousand divided by pounds of water evaporated per pound of coal would give the number of pounds of coal required for evaporation of 1000 lb. of water. When the cost of coal is quoted per long ton (2240 lb.) then the price per pound would be the cost per ton divided by 2240. Therefore, the cost of the coal required to evaporate 1000 lb. of water would be

$$\frac{1000}{\text{water per lb. coal}} \times \frac{\text{cost per ton}}{2240},$$

or,

$$\frac{\text{cost per ton}}{\text{water per lb. coal} \times 2.24}$$

and for 2000 lb. of coal per ton, the cost of the coal to evaporate 1000 lb. of water would be,

$$\frac{\text{cost per ton}}{\text{water per lb. coal} \times 2}$$

Engineers' Study Course

Problems in Power-Plant Design--VII

Piping Layout

Among the principal points to be realized in laying out a system of power-plant piping are the following: Pipes of ample size to convey the steam from the boilers to the engines without appreciable loss of pressure, reasonable compactness to prevent excessive condensation, the avoidance of pockets, a proper system of drainage to keep all parts of the piping free from water and sufficient flexibility to prevent overstraining due to expansion and contraction. While valves should not be used so freely as to complicate the system, they should be placed in such a manner as to provide all the combinations necessary, and upon all important pieces of apparatus, so that they may be cut out when desired. There are several standard arrangements for power-plant work, that shown in diagram in Figs. 1 and 2 having been chosen for the present problem. The supply system in this case consists of an overhead loop of large size having a connection with each boiler and engine. This is divided into four sections by valves, and provides two paths for the flow of steam from the boilers to the engines. Flexibility is secured by the use of sweep bends, which are

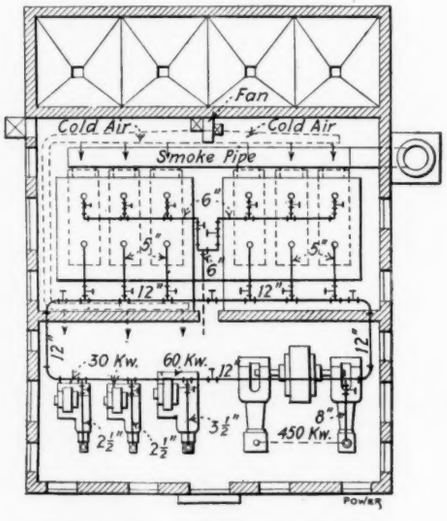


Fig. 1. Plan View of Piping

clearly indicated in the sectional elevation, Fig. 2. Each boiler connection is provided with two valves to prevent any possibility of steam leaking back into the boilers when shut off for cleaning or repairs.

Large separators are placed in each engine connection close to the throttle valve, and the pipes joining these with the main header are made one size smaller than called for by the engine builders. The object of this aside from drainage and dryness of steam is to have a full supply of steam close to the cylinder in order to provide a cushion on which the blow caused by the cutoff may be spent, thereby preventing vibrations from being transmitted through the piping system; and, finally, to produce a steady and rapid flow of steam in one direction. Here, as in the case of the boiler connections, an extra valve is placed in each lead close to the main. An independent auxiliary header is connected with the front nozzles of the boilers for supplying steam to the various pumps, and to the heating system when live steam is required.

The exhaust piping, steam and water to pumps, heating mains and blowoff piping, are shown in Fig. 3. This

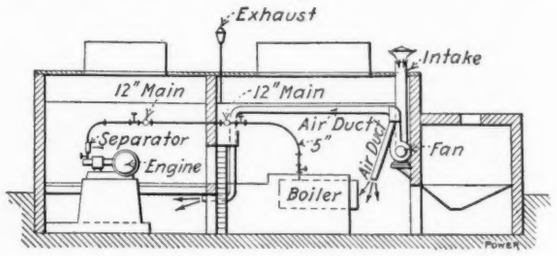


Fig. 2. Sectional Elevation of Plant, Showing Arrangement of Piping

drawing is diagrammatic in form and is intended to illustrate the principles involved and the combinations to be obtained.

Starting with the exhaust from the main engine, it first passes through an oil separator, then divides into two branches, one leading to the heating system, and one to the condenser, the latter also connecting outboard as indicated. The exhaust from the lighting engines may be turned into the condenser or outboard as desired. The exhaust from the various pumps may pass outboard through a back-pressure valve or may be utilized in a secondary feed-water heater. The main feed-water heater may be supplied with steam either from the heating system or from the main leading to the condenser; connections with both heaters being on the induction principle. As the larger heater will usually be supplied with steam below atmospheric pressure, it must be drained through a return trap having a high-pressure connection. The heating main has a live-steam supply through a reducing valve, and an overflow through a relief or back-pressure valve into the outboard exhaust. A relief valve is also provided between the condenser and outboard main.

By these arrangements the exhaust from the main engine may pass either into the heating system, to the condenser or outboard; and that from the lighting engines either to the condenser or outboard. The live-steam supply to the heating system is entirely separate, and may be used either in connection with the exhaust or independently.

Cooling water for the condenser flows from the outside reservoir to the circulating pump, and is discharged into a special drain leading to the river. A cross-connection is provided for supplying fresh water directly into the

receiving tank when required, the reservoir being high enough to produce a gravity flow.

The condensed steam from the air pump may be discharged either into the receiving tank (which is vented to atmosphere) or into the drain above mentioned. During the summer, when the condenser is in continuous operation, the receiving tank will serve as a hotwell from which the boilers are fed.

The connections between the feed pumps and boilers are not shown in the drawing. The main feed line passes through the heaters in series, the larger one coming first. Independent bypasses are provided around each heater so they may be cut out for repairs, or at other times when not in use.

The size of steam pipes for power-house work, where the length of run does not exceed 150 to 200 ft., is usually based upon a velocity of flow not exceeding 6000 ft. per min. for supply mains and 4000 ft. for exhaust. To use these velocities it is necessary to reduce the weight of steam at a given pressure passing through the pipe per minute, to cubic feet, which may easily be done by use of a steam table. This volume, divided by the assumed velocity, will give the required area of pipe in square feet. This result multiplied by 144 will give the area in square inches, from which the required diameter of the standard size may be obtained from any table of pipe data and dimensions. A simple rule, which works out well in practice, is to allow 0.12 sq.in. per i.hp. of engine for steam

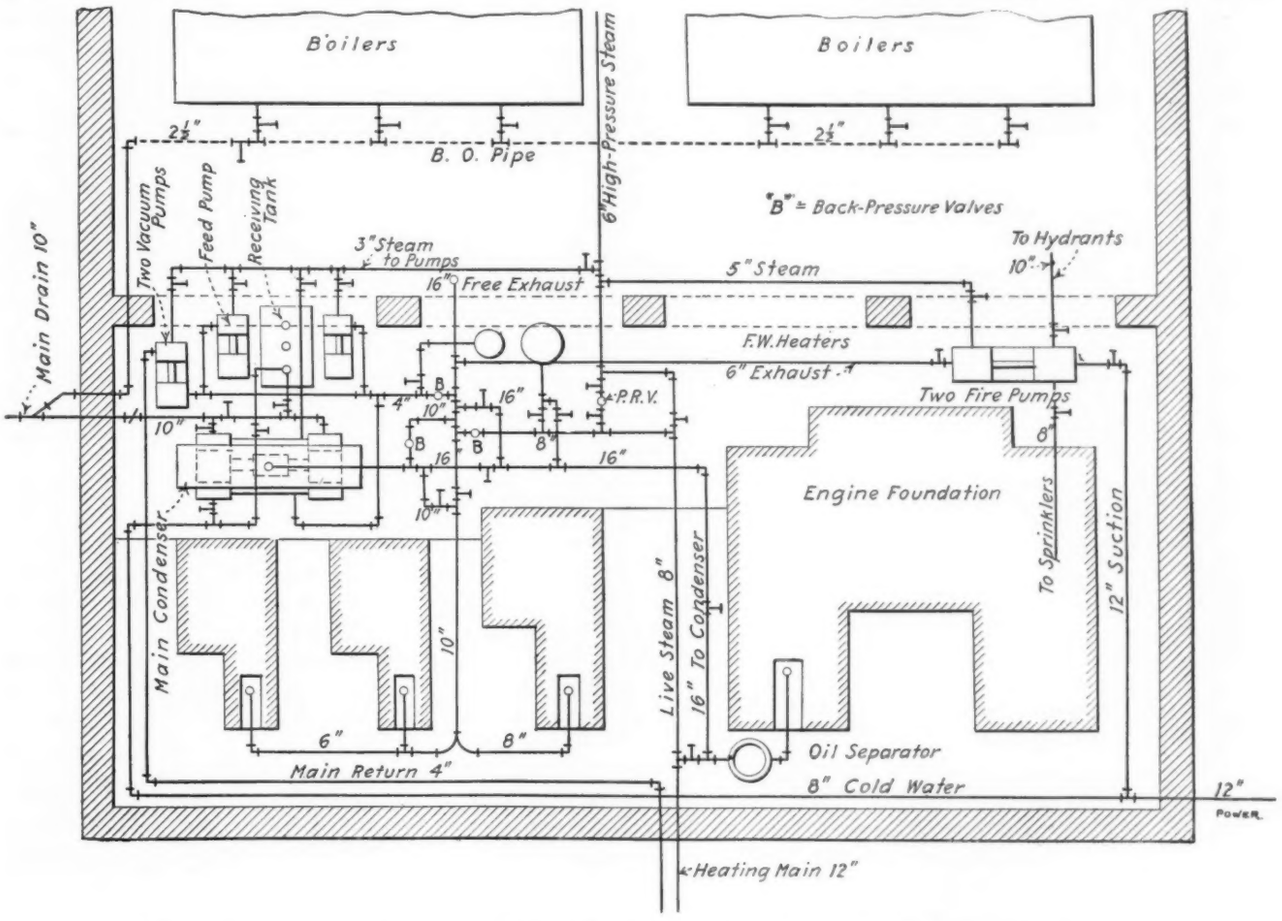


FIG. 3. EXHAUST AND HEATING PIPING AND STEAM AND WATER CONNECTIONS TO PUMPS

The branch to each boiler is furnished with a shutoff and check valve, the former being placed next to the boiler. An injector of sufficient capacity is placed in a bypass of the feed pipe near the boiler fronts for use in case of an accident to both of the pumps. Duplicate vacuum pumps should be furnished, and this is indicated by notes on the drawing, although only one is shown.

All steam separators and mains which are free from oil should be drained through traps to the receiving tank, unless a gravity-return system is installed, which returns the condensation directly to the boilers. Drainage from the oil separator, and all other oily drips, should be discharged into the main drain pipe. The blowoff pipe from each boiler is provided with a special blowoff valve, and is arranged for discharge as shown in the drawing.

pipes, and 0.18 sq.in. for exhaust pipes. This applies to modern engines of good economy and is on the side of safety. The factor 0.12 may also be used with good results for proportioning the boiler connections, because 30 lb. of steam per hr. at 70 lb. pressure represents the average water rate of a simple noncondensing engine, as well as the quantity furnished by one boiler-horsepower.

Applying the above to the boilers in our model plant gives

$$120 \times 0.12 = 14.4 \ sq.in.$$

which comes between the areas of a 4- and a 5-in. pipe, and the larger size has been used for the leads between the boilers and main.

The size of piping is also fixed to a considerable extent by the outlets left by the makers upon engines and other pieces of apparatus. When this method is employed, and

several branches are joined into a single main, an equation of pipes is made use of, and for convenience in design a table of this kind covering the sizes used in ordinary power work is given in Table 1.

TABLE 1—AN EQUATION OF PIPES

Dia. in.	2	3	4	5	6	7	8	9	10	12	14	16	18	20
2	1													
3	3	1												
4	5	2	1											
5	10	3	2	1										
6	15	5	3	1.5	1									
7	23	8	4	2	1.5	1								
8	32	11	5	3	2	1.5	1							
9	43	15	7	4	3	2	1.3	1						
10	56	20	10	5.5	3.5	2.5	1.7	1.3	1					
12	71	32	15	9	5.5	4	2.8	2	1.6	1				
14	130	47	23	13	8	5.5	4	3	2.3	1.5	1			
16	181	65	32	18	11.5	8	5.7	4.2	3.2	2	1.4	1		
18	243	88	43	24	15	10.5	7.6	5.7	4.3	2.8	2	1.3	1	
20	316	115	56	32	20	14	10	7.4	5.7	3.6	2.4	1.7	1.3	1

For example, the carrying capacity of a 10-in. pipe is equivalent to ten 4-in. pipes, 5½ five-inch pipes, and 1.3 nine-inch pipes, etc.

When a fractional number of pipes is involved, the change to a whole number should be on the side of safety. For example, a 14-in. pipe is equivalent to 2.3 ten-inch pipes, and it would, therefore, be safe to join two 10-in. branches into a 14-in. main. On the other hand, a 16-in. pipe is equivalent to only 5.7 eight-inch pipes, but the difference is so small that it would be safe to join six into a 16-in. pipe for lengths of run less than 100 ft.

When steam is to be carried long distances, as in supplying a group of buildings from a central plant, Tables 2, 3 and 4 may be made use of. They are abridged from similar tables published by the writer in POWER, September, 1908.

Table 2 gives the pounds of steam discharged per minute through pipes of different diameters, 100 ft. in length, for drops in pressure of ¼, ½, 1 and 2 lb. between the two ends of the pipe.

TABLE 2—FLOW OF STEAM THROUGH PIPES IN POUNDS PER MINUTE

Dia. of Pipe, In.	Drop in Pressure ¼ Lb.	½ Lb.	1 Lb.	2 Lb.
3	8.6	12.3	17.6	25.4
4	18	26	37	53
5	32	46	66	95
6	52	73	106	152
7	77	109	157	226
8	108	154	222	319
9	147	209	300	432
10	192	273	393	567
12	305	434	623	900
15	535	761	1090	1580

These values are for initial pressures below 2 lb. For higher initial pressure, multiply the quantities given in Table 2 by the factors in Table 3.

TABLE 3—FACTORS FOR INITIAL PRESSURE OF 10 TO 100 LB.

Drop in Pressure, Lb.	Initial Pressure, Lb. 10	30	60	100
¼	1.27	1.68	2.13	2.60
½	1.26	1.66	2.11	2.58
1	1.24	1.64	2.08	2.53
2	1.21	1.59	2.02	2.47

For lengths of run other than 100 ft. multiply the quantities in Table 2 by the factors in Table 4.

TABLE 4—FACTORS FOR LENGTH OF RUNS OTHER THAN 100 FT.

Length of Run, Ft.	Factor
20	2.2
50	1.4
100	1.0
200	0.7
300	0.6
400	0.5
600	0.4
800	0.35
1000	0.31

EXAMPLE—What sized main will be required to deliver 130 lb. of steam per min. a distance of 400 ft., with an initial pressure of 100 lb. per sq.in. and a drop in pressure of ¼ lb.?

From Table 3 the factor for 100 lb. initial pressure and ¼-lb. drop is 2.6, and from Table 4 the factor for 400-ft. run is 0.5. Therefore, the quantity to look for in Table 2, under ¼-lb. drop, is

$$\frac{130}{2.6 \times 0.5} = 100$$

which corresponds closely to the 108-lb. capacity of an 8-in. pipe.

WEIGHT OF PIPE, FITTINGS AND VALVES

Standard-weight steel or wrought-iron pipe is considered sufficiently strong for the pressures ordinarily carried in power-plant work. Although guaranteed for only 125 lb. per sq.in., tests show it to be amply safe for pressures somewhat higher. In the present case, where the working pressure is to be from 120 to 130 lb. it can be safely used.

Cast-iron fittings are commonly made in three weights: light, for exhaust and condenser piping; standard, for pressures up to 125 lb., and extra heavy, for higher pressures up to 250 lb. All feed piping around pumps and boilers should be of brass, iron-pipe size, made up with standard brass fittings. In general, gate valves are best for high-pressure work, and for the larger sizes, say 4 in. and above. The outside screw or yoke pattern is to be preferred.

For sizes 8 in. and above, the bypass type should be employed on account of greater ease in operation, and less liability of scoring the seat when opening and closing.

VENTILATION

The method of ventilating the boiler room is shown in Figs. 1 and 2. A sufficient volume of air is supplied to change the contents of the room four times an hour. The fan is mounted upon the wall in front of the coal bunker, and takes its supply through an intake carried above the roof. Air is delivered in front of each boiler through a downtake pipe, and to the space beneath the engine room occupied by the pumps and condenser. Discharge ventilation is through the monitor. The engine room is ventilated entirely by means of windows and monitor.

First American Boiler Steel—At the recent meeting of the American Boiler Manufacturers Association, it was brought out that the first steel used for boiler purposes in the United States was made by Hussey, Wells & Co., by the crucible process, and put into a mud drum on the boilers of the steamer "Tom Reese" in 1868.

Water-Power Surveys in Snake River Basin—Topographic engineers of the United States Geological Survey have been making profile surveys in the Snake River basin, Idaho—surveys, incidental to their general topographic mapping—and the results of their work have just been published by the survey in Water-Supply Paper 347, which also contains a map of the area examined.

The Snake River basin has many good storage sites, but only a few have been utilized. About 400,000 acre-feet of water can be stored in Jackson Lake by a dam which has been constructed by the Reclamation Service. The largest site is at Swan Valley, on Snake River, where the water available for storage is approximately 4,000,000 acre-feet. Irrigation has reached a high stage of development in the Snake River valley, yet approximately 6,000,000 acre-feet of water annually runs to waste. Eventually these flood waters will be stored and used to irrigate thousands of acres of arid land. The streams afford enormous water powers, but only a few sites have been developed owing to the lack of market.

A copy of the water-supply paper may be obtained free on application to the Director of the United States Geological Survey, Washington, D. C.

A Practical Method of Determining the Fatigue Limit of Metals*

SYNOPSIS—When a piece of steel is stretched it cools until the elastic limit is reached; if the stretching is continued beyond this point, the temperature rises. The author turns a groove in a circular specimen, holds it as in a lathe chuck and hangs a weight upon the extended rod at some distance from the groove. The specimen bends at the circular nick, the top being put into extension and cooling, the bottom into compression and heating. When the specimen is revolved, the heating offsets the cooling and the temperature remains constant until the load applied becomes so great that the limit of elasticity or fatigue limit is exceeded when the temperature commences to rise. By observing the time such heating begins, the fatigue limit can be thus quickly determined.

One of the most novel and interesting, and possibly the most important, steps in the determination of the properties of materials by means of physical tests, has been proposed and practically demonstrated by C. E. Strohmeyer, chief engineer of the Manchester Steam Users Association.

Mr. Strohmeyer has apparently solved the problem of making the determination of the fatigue limit of materials practical. Woehler, who was the chief engineer of a Prussian railway, made an extended series of tests to determine the fatigue limit of steel, the results of which were published in 1871; these tests were made in an investigation of the behavior of car axles and springs. In Woehler's tests, some of the samples were stressed many times, a few being vibrated upward of 50,000,000 times without any assurance that they would ever break. On account of the length of time involved, few experimenters have attempted to duplicate Woehler's experiments, since a test of the length indicated above required about one and one-half years continuous running.

The difficulty about the practical use of the results of Woehler's tests and those that have been made later, was that no satisfactory correlation could be established between the results of the different tests. As a makeshift it was proposed to make several fatigue tests of a material arranged so that the amount of stress that would break the sample when applied about 1,000,000 times could be determined approximately. Dr. Martens, of Berlin, in order to overcome the difficulty, has recently adopted as a standard of comparison the number of times that a stress of 19 tons per square inch can be repeated before fracture occurs.

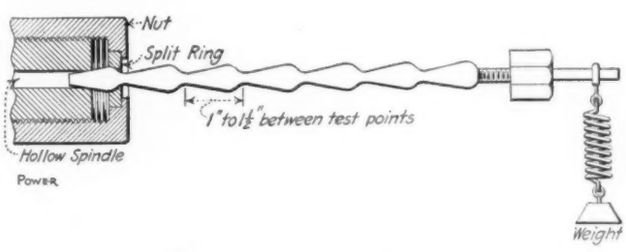


FIG. 1. MODE OF TESTING

Mr. Strohmeyer reasoned that the lack of harmony among fatigue limit tests might be due to irregularity in the fatigue-resisting properties of the different samples tested. To insure uniformity so far as possible, he arranged his samples for bending tests as shown in Fig. 1, the different test points on each specimen being arranged so that they were only 1 to 1½ in. apart, and therefore six tests could be secured of a sample in a length of 6 to 9 in.

Owing to the uniformity secured by means of the shortness of the sample, the results of Mr. Strohmeyer's tests could be harmonized, and by comparing his test results he found that the following formula applied

$$N = \frac{10^6 C^4}{(Sn - Fl)^4} \qquad (1)$$

in which N equals the number of repetitions of the stress Sn; Sn being the nominal test stress applied to the specimen, Fl the fatigue limit of the material under test and C a constant for the particular sample under test. This formula can also be written

$$Sn = Fl + C\left(\frac{10^6}{N}\right)^{\frac{1}{4}} \qquad (2)$$

and Sn may be K, according to whether the stress is tensile or compressive.

It can be seen from inspection that, if formula (2) is true, a determination of the number of vibrations required to fracture a sample under two widely varying stresses representing Sn would give a knowledge of all the intermediate values and also of the fatigue limit Fl. For example, if, as in Fig. 2, a sample which is stressed to 25 tons failed at 5000 applications of this load, and when stressed to only 13 tons failed at 1,000,000 applications, all other values representing the number of applications at which this sample would be supposed to fail when subjected to any other stress would lie on the straight line joining these two points, since the verticals representing the number of applications are arranged at such distances from the "y" axis as to represent the fourth root of the reciprocal of the number of applications. When the results of the tests made on the close-spaced specimens, as illustrated in Fig. 1, were plotted, it was found that they did lie on practically straight lines.

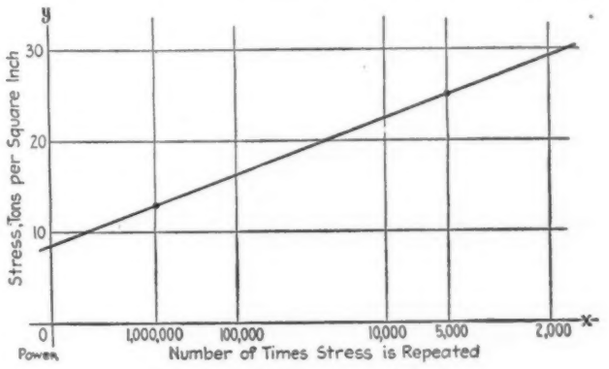


FIG. 2. RECORD OF TESTS

In making these tests it was found necessary, in order to secure accuracy, to run one sample at such a stress that it would fail at about 1,000,000 repetitions of the load, and on account of the length of time involved, even assuming that the formula was correct and that the fatigue limit could be obtained from the extrapolation of the values found, this means of obtaining the fatigue limit could not be considered entirely practical for use in the regular testing of materials.

Happily, a short method of directly determining the fatigue limit of a material occurred to Mr. Strohmeyer while making these tests. This method was based on the principle that within the elastic limit there is practically no internal friction with elastic material, such as steel, but that as soon as the elastic limit is reached the molecular friction is set up and is manifested by the production of heat. If some means could be devised to detect the first signs of a temperature rise in a specimen under test, Mr. Strohmeyer reasoned that the stress applied at that instant would represent the fatigue limit or the true elastic limit of the material under test.

Acting on this idea, some samples were tested, which were surrounded by a loose-fitting sleeve of rubber. Water was passed in the space between the tube and sample while the test was in progress and the temperatures of the water at the inlet and outlet were taken.

When a difference of one degree Centigrade was noted, the fatigue limit was supposed to have been reached and it was found that the fatigue limits indicated in this way were very clearly defined.

What was considered of much more importance than the good definition of the fatigue limit, was that the fatigue

*An abstract of the memorandum of the chief engineer of the Manchester Steam Users Association for 1913, issued June, 1914.

limits arrived at by this means agreed remarkably well with those as found by extrapolation of the series of tests carried to the point of failure. The reason of the importance of this agreement is that it indicates that the formula as stated above applies to an infinite number of applied stresses as well as between the limits through which it was derived.

With this means of determining the fatigue limit of materials available, it is only necessary to start to test a sample and gradually increase the stress applied until the fatigue limit is reached and then to increase the stress at once to such a point that failure will occur after a few thousand applications.

By noting the number of applications required to break the specimen at this high stress and the application of the formula given above, all the intermediate values may be obtained. Torsional fatigue tests were made on the same principle and the fatigue limits determined in the same manner.

In comparing the fatigue limits of several sets of these torsional tests where a number of tests had been made on each sample, it was discovered that the agreement between the fatigue limits, as found for such samples, were equally as good as the agreement between the tensile strengths found by testing a number of samples cut from a plate, side by side.

The agreement was also as good as that found for the tensile strength of forty-one steel bars as tested by Dr. Martens, who tested this number, of five-foot lengths, by taking a sample from each end and two from the middle. It was hoped by Mr. Strohmeyer that fatigue limit determinations under tensile stress would furnish results in still closer agreement, a machine being in process of construction which would permit tests of this character being made. To illustrate how this method of testing and the formula derived may be a very practical aid in selecting the best material for a given purpose, two examples from the many tests made were selected. The first specimen of steel selected was found to have a fatigue limit of 12.60 tons per square inch and the value of constant C was found to be 0.504, or the formula giving the number of vibrations to failure would be

$$N = \frac{10^6 \times 0.504}{(Sn - 12.60)^4}$$

The other sample selected showed a fatigue limit of 11.10 tons per square inch and a constant C of 2.42. If the duty expected of a material was such that no shock was to be experienced that would stress the metal beyond its true elastic limit or its fatigue limit, the first material with the highest fatigue limit would be selected.

If, however, the nature of the work was such that the elastic limit must be exceeded, the material with the highest coefficient C would be selected. As will be seen by assuming a working stress Sn of sixteen tons per square inch, the first sample given above would be expected to stand only 480 repetitions, while the second should be able to resist about 60,000 applications of such a stress before failure would result. The time involved in making a complete fatigue limit test of a sample by Mr. Strohmeyer's method is only one to two hours, which places such tests on a basis that will permit their practical use. The author states that before recommending the fatigue test for the practical determination of the suitability of a material for any particular purpose, the work of correlating the results of such tests with practical experience in failures will have to be completed. Work of this character has already been started in the investigation of a number of failures of copper pipes, which failed on account of the movement of the engines to which they were attached.

⁂

Electricity in the Anthracite Industry—The introduction of electricity in any great quantity into the mines is not more than two decades old. The first electrical installation was made in 1887 by the Pennsylvania R.R. In 1889 the Thompson-Houston Co. installed a locomotive and a generating station in the Erie Colliery of the Hillside Coal & Iron Co. and this locomotive was in continuous service until 1911. The first electric pump was installed in 1890, and it has been in continuous operation ever since.

The present total capacity of supply purchased or generated is 105,400 hp. compared with 440,300 hp. produced by steam for direct use. Today there are 169 miles of wooden pole lines above ground and 754 miles of trolley wire below ground in the anthracite mines. There are 951 electric locomotives using an estimated amount of over 60,000 hp. The other electrically operated equipment requires 19,170 hp. for breakers and miscellaneous machinery, 23,280 hp. for electric hoists, 38,500 for electrically driven pumps, 2920 for coal-cutting machines, 3650 for lighting and about 100 for heating. There are now five breakers equipped with individual motor drives, and others are under course of construction.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

See that the Maxim silencer has taken root in our field. We need a noise trap for more than one kind of "sound wave" in our midst. Hope, though, it does not clap the muffler on our old-time friend, What-Caused-the-Knock.

⁂

The New York "Sun" sure has a grim sense of humor. Read this:

The executioner at Charlestown, Mass., state's prison has notified the warden that on account of hard times he will reduce his price for electrocuting condemned prisoners. It is believed he is not seeking to stimulate business, but rather to preclude his substitution by a cheaper man.

And this item is printed under the heading "Sunbeams"!

⁂

The first chairman of one of the first of the public service commissions seven years ago made this prophetic pronouncement: "The public will ultimately have what it wants. If it has set up machinery which does not produce the results it desires, that machinery will surely be relegated to the junk heap and a new installation made."

One big reason for creating this type of commission was to secure relief from unjust treatment by the powerful public service companies. Looks like old man Public will have to wake up and exercise his prerogatives.

⁂

Here's a new use for a barometer, as set forth by the "Chicago Herald:"

A bricklayer lay ill, and the doctor, having done what he could, told the man's wife to take his temperature in the morning. Calling the next day, the doctor asked if his instructions had been followed.

"Well, we hadn't a 'tremometer,'" the good woman replied, "but I put a barometer on his chest and it went up to 'very dry.' So I gave him a bottle of beer and he's gone to work."

⁂

When it comes to a "get together," the alert engineer is some swarmer! Electrical, mechanical and civil, they gathered in Boston recently to hear Brother Waite tell how, as city manager of Dayton, Ohio, that city of 125,000 men, ladies and kids is taken care of on a strictly business basis. "Exit the Politician—Enter the Engineer" is the title of one of this week's editorials. The news story is on page 795. Read 'em both! They are most digestible food for thought, so take a big mental bite out of each.

⁂

Lives of engineers remind us
That their lives can't be sublime
While they're poked down in a basement,
Working seven days at a time!

⁂

A lady fireman has been forbidden to operate a New York schoolhouse boiler, though she has a police department license to run any boiler not over 90 lb. pressure. The board of education has put on the kibosh. Is this one more reason why the power to grant licenses should be taken away from the cops?

⁂

Of course you were pleased with the "National Engineer's" reproduction of the engrossed resolutions of appreciation the N. A. S. E. presented the Allis-Chalmers folks for courtesies extended during the Milwaukee convention. It was a fine touch of appreciation.

⁂

The Milwaukee Efficiency Society recently listened to a lecture on "The Human Eye and Protective Measures for Keeping It in Working Condition." They sure gave good measure with all the eye-openers we glimpsed during our recent brief visit to that charming city while under the care of Drs. Wickert, Peterson and Mistele.

⁂

"The policy of home rule of utilities—that is to say, local instead of state regulation of privately owned plants—proved to be in several cases only a frankly admitted disguise to cover a real policy of public ownership and operation," remarks the "Electrical World" of the recent Mayors' Conference in Philadelphia. Let's wait and see what is the outcome of the Utilities Bureau. Mebbe New York City could have decided the Edison rate case long ago if this growing little village did not have to appeal to those state-appointed, fifteen-thousand-dollar Public Service fellers.

City Management and the Engineering Profession

A large attendance of engineers representing all branches of the profession gathered at Chipman Hall, Boston, on Nov. 18, to hear an address by Henry M. Waite, city manager of Dayton, Ohio, upon "The City Manager Plan and Its Relation to the Engineering Profession." The meeting was under the auspices of the Boston Society of Civil Engineers and the Boston sections of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers. Mr. Waite discussed the city charter of Dayton at length, pointing out the efficiencies in municipal administration secured under the commission-manager plan, which in 11 months' trial at Dayton has appeared to completely realize the divorce of municipal administration from politics and the concentration of responsibility for all public business, long seen by acute observers to be one of the most desirable attainments to be secured in American life.

On the engineering side, the speaker touched upon the benefits of financing and administering water-works and sewer systems on a purely business basis, paying as the city goes, and he pointed out that most of the great problems of the modern city are of an engineering nature. The publicity of the city-manager plan is one of its strongest features. In conclusion, the speaker urged engineers entering this field to cultivate the power of presenting cases on their feet to public boards, stating that inability to speak is a serious handicap to personal efficiency. Former Mayor James Logan, of Worcester, Mass., also addressed the meeting upon the importance of devotion to civic responsibilities by the engineer.

Chicago Section A. S. M. E. Meets in La Salle Hotel

On Friday evening, Nov. 20, the Chicago section of the American Society of Mechanical Engineers held its first meeting of the season in the Louis XVI Room of the La Salle Hotel. The meeting was of the informal dinner variety so popular last season. Fully 140 sat at table. Promptly at 8 o'clock Chairman S. G. Neiler opened the meeting with a few words of thanks to last year's committee for suggestions and assistance in getting things under way.

WINSLOW HIGH-PRESSURE BOILER

W. H. Winslow, the first speaker, aroused a great deal of interest as he explained the construction and operation of his new high-pressure boiler. He dwelt briefly on what had been done in the way of experimental work during the last four years and of the fields to which the boiler would be applied. Mr. Winslow touched upon the possibilities of high pressures and of the Stumpf una-flow engine, which appears to be the prime mover best adapted for high pressure and superheat. Naturally much of the talk, which was thoroughly illustrated with lantern slides, was along the same lines as the article on other pages of this issue describing the boiler, so that repetition here will be unnecessary.

Henry A. Allen, consulting engineer for the City of Chicago, was scheduled to lead the discussion. He referred briefly to the old rectangular marine boiler carrying 20 lb. pressure, the Herreshoff boiler of later date and a modern boiler in a water-works plant under 220 lb. pressure. It was his belief that the new boiler was specially adapted for portable use, such as for the automobile truck or bus and the large tractor plow. In either service, steam had the advantage over the internal combustion engine. With its multiplicity of parts, the Winslow boiler had all the advantages of the Herreshoff in portable work. This construction eases up on the work of regulating the feed pump. The small flexible tubes to the steam header were to be commended for work where vibration could be expected. It was his final conclusion that for different lines of work, boilers must be specially designed, the portable field requiring different construction than a boiler for stationary use. In the latter it was an advantage to have a considerable quantity of water in circulation. The present boiler possessed novel features, having many good points for different kinds of work. With its small tubes it belonged to the safe type and possessed the advantage of flexibility. The final test, however, was use, and he wished Mr. Winslow every success, as better portable outfits were badly needed.

Robert Cramer, engineer of the Winslow company, was more optimistic on the possibilities of the boiler than his predecessor. While believing that it was the best portable boiler, it was his conviction that the Winslow boiler would find its way into the largest power plants and would show results at least 12 per cent. higher than the best obtainable today. The cleaning facilities could be easily improved and other difficulties would be met as they come to them. A few sections in reserve instead of entire units was an important point. The boiler consisted of parts of small bulk and weight which could be taken through small areas, and the boiler built up in place. For marine use they could get in a given space larger boiler capacity than was possible with any other type. Four years had been spent in developing the boiler to a point where they at least were satisfied that it was better than anything else offered for the purpose heretofore.

BOILER EFFICIENCY METERS AND EUROPEAN BOILER PRACTICE

W. A. Blonck, maker of the boiler efficiency meter, introduced his remarks of the evening by a vivid account of his experiences in Europe, from which he had just returned. Briefly he explained the principles of his meter, with the red and blue fluids showing the drop in draft through the furnace and the setting, respectively. His new recording meter was flashed upon the screen with a number of other slides, and charts made up from the records of his instruments were shown. It was with considerable pride that he displayed a certificate of merit from the Franklin Institute, granted after an investigation by the committee on science and arts, on the novelty of his work in establishing the zero point for the efficiency meter.

In the latter part of his talk, Mr. Blonck turned to European boiler practice. By means of slides he showed the fine architectural design of the buildings and the efforts made to add to the appearance of the stack. Cross-sectional views showed the unit design generally followed and the small bunker capacity for coal. The latter was stored on the ground and conveyed to the boiler as needed. The injector draft chimney was in frequent evidence and ash-handling facilities were a negative quantity, due largely to cheap labor. Small steam pipes with velocities up to 14,000 ft. per min. were also a feature.

Much of the latter part of the talk centered around the high-duty boiler with built-in economizer. The gases made a single pass through the heating surface to an economizer having nearly as much surface as the boiler. Diagrams were presented to show the difference in temperature between the gases and the water in the type under discussion and in the normal boiler with independent economizer. For the high-duty boiler a greater difference was apparent, indicating better heat absorption. In each case the exit temperature of the gases was about the same.

Evaporation tests and heat balances of a high-duty boiler at Hamburg were presented. The boiler contained 3700 sq.ft. of heating surface, 1050 sq.ft. of superheating surface, 3110 sq.ft. of economizer surface and 149.5 sq.ft. of grate surface. The ratios of heating to other surfaces in their respective order are 3.52, 1.19 and 24.8. The grate has double the area that would obtain in standard practice in this country. Fuel beds are only 3 or 4 in. thick and require an immense amount of attendance. At normal load an evaporation f. and a. 212 deg. of 10.24 lb. of water per pound of coal as fired was obtained. The efficiency of the boiler was 70.6 per cent.; of boiler and superheater, 77.3 per cent., and of the total installation 86.3 per cent. The coal had a heat value of 13,650 B.t.u. The loss in the flue gases was 10.5 per cent. and in radiation 3.2 per cent. The temperature difference between the outgoing gases and the water in the economizer was about 130 deg.

In the discussion, Joseph Harrington thought that the German boiler, due to its arrangement, had the advantage of economy in floor space. The individual "megaphone" stacks did not look pretty, but there was one for each boiler, so that the area was always in proportion to the boiler it served. Too much area frequently found in a stack designed for present and future installations was almost as bad as too little. The criterion of overall efficiency was the amount of waste heat going up the stack. In the test figures given this was found to be exceptionally low. The large grate surface, 100 per cent. excess air and 10 per cent. CO_2, were out of harmony with our ideas. As to the Blonck meter, it was all right. It was just as accurate an instrument as any ever built, and, if rightly interpreted, should be of great value in the boiler room.

MECHANICAL FILTERS

Walter H. Green, chief engineer of the International Filter Co., talked on mechanical filters, dwelling on methods of rating and some of the experiences his company had had with prospective customers. He explained that a mechanical sand filter was more rapid because a coagulant was used, but that there was a limiting rate at which a filter could be properly worked. Reference was made to the tendency of installing filters that were too small. In some cases the

filter had to be bypassed, as the necessary amount of water could not be forced through. It was a question whether to use sand or quartz. Either will work, as both are practically the same thing, except that the sand is used in its natural state and the quartz must be ground. There was a difference in sand, however, and some discretion was required in making a proper selection. Sand with grains of uniform size was desirable, and if this was obtained, it gave better results than quartz, as, due to the mechanical grinding, uniformity in the size of the particles could not be expected.

Clinkering Properties of Coal

At a joint meeting of the Philadelphia Engineers Club and the local branch of the A. S. M. E., on Saturday evening, Nov. 21, F. C. Hubley, assistant engineer of tests of the American Bridge Co., read an instructive paper on the clinkering of bituminous coals.

As the speaker pointed out, coal is now commonly purchased on specifications, based on analyses and a B.t.u. determination. This information, while desirable, is not conclusive as to the probable behavior of the coal; therefore, it should be accompanied by a knowledge of the clinkering properties and the fusing temperature of the ash. The latter is more or less indeterminate and is not as important as the fusing range, represented by the temperatures between which the ash starts to soften and runs freely. Experience has shown that a long-range, slow-fusing ash produces a troublesome gummy clinker, whereas one having a short-range forms a porous clinker which can easily be broken up. In view of this, one should select a coal having a short range, the upper limit of which is well above the maximum temperature likely to occur in the furnace in which it will be used.

Mr. Hubley described two methods of predetermining the fusing range which have been employed by the American Bridge Co. The first of these was the "cone" method which owing to the time required, has now been superseded by the "fusiometer," an instrument for recording the softening of the ash with corresponding rises in temperature.

CONE METHOD

A sample of the coal is first ground to pass through a 50-mesh screen and is then burned to ash at a dull red heat. The ash is next mixed with water to form a paste which is placed in a hard-wood, cone-shaped mold; glazed paper between the ash and the mold prevents sticking. It is then baked at about 250 deg. until the ash forms a solid cone, upon which it is removed from the mold and placed in a gas furnace for three minutes. The temperature of the furnace is under control and is measured by a thermo-couple. By subjecting a number of cones to different temperatures and noting the relative deformations, the fusing range can be arrived at and a curve plotted. The color of the cone is also an indication of its fusibility, a light brown accompanying little or no deformation and a dark brown or purple denoting complete softening of the cone.

FUSIOMETER

In this case the dry ash is prepared as before and then compressed under a pressure of 25,000 lb. per sq.in. into a pellet, 5/8 in. diameter and 1/2 in. high.

The fusiometer consists essentially of a frame carrying a small gas-fired furnace into which project two carbons set on a common axis. Between the carbons is placed the ash pellet under a pressure of 1½ lb. The upper carbon is free to move up and down and is attached to a pointer which magnifies twelve times on a scale any expansion or contraction of the pellet. The temperature of the furnace is measured by a thermo-couple. Thus by subjecting the pellet to gradual increases of temperature, the corresponding expansion or contraction can be noted and the fusing range determined from the curve plotted.

At first the carbons will expand, but later the pellet will soften and decrease in thickness until it finally collapses. In these fusiometer determinations the fusing temperature has been chosen arbitrarily as the point at which the pellet has settled to half its original height; at this point the ash begins to flow. A furnace temperature of 2700 deg. F. may be attained with illuminating gas and over 3000 deg. with blau gas.

In commenting upon the composition of the ash as affecting the fusing qualities, Mr. Hubley said it had been the experience of this company that iron oxide and calcium sulphate tended to produce low-fusing temperatures. Of the constituents of ash, aluminum appears to be the most infusible, fusing at about 3200 deg.; silica comes next, fusing at about 2900 deg.; and the other elements may be regarded as fluxes of which iron is the most potent. In his opinion sulphur did not follow any rule, although when combined with iron in the form of pyrite it invariably produced a low-fusing temperature.

The fusing temperature to be specified in the purchase of coal will depend on the load conditions. Where the boilers are forced, a high furnace temperature will be had, in which case with Pennsylvania coal the speaker recommended 2600 to 2700 deg. Of course for lower rates of driving and different coals somewhat lower temperatures should be specified.

PERSONALS

Prof. L. H. Harris, formerly professor of electrical engineering in the University of Pittsburgh, has been appointed consulting engineer to the Public Service Commission of Pennsylvania. In conjunction with Prof. R. H. Fernald he has just completed the commission's first important publication, a booklet on service rules and regulations pertaining to electricity, gas and heat.

ENGINEERING AFFAIRS

The Detroit Engineering Society schedules the following meetings:

Dec. 4. M. Luckiesh, of the Nela Research Laboratory, Cleveland, Ohio, "Importance of Direction, Quality and Distribution of Light."

Dec. 18. Dean M. C. Cooley, department of engineering, University of Michigan, "Engineering in a Broader Aspect."

Jan. 8, 1915. E. T. Howson, engineering editor, "Railway Age Gazette," Chicago, "Heavy Construction Work in Railroad Building."

Jan. 22, 1915. Prof. H. S. Sadler, University of Michigan, "Gleanings from the University of Michigan Naval Tank."

Brooklyn Combined Engineers—The seventh annual entertainment and reception of the Combined Associations of Engineers of the Borough of Brooklyn, N. Y., was held on Saturday evening, Nov. 21, at Kismet Temple, Brooklyn, N. Y. The entertainment program, consisting of four vaudeville numbers and a minstrel show by the N. A. S. E. "Bunch," was greatly enjoyed by the large attendance, which included many prominent engineers and representatives from the various supply houses. Dancing concluded the night's fun. A. F. Theirgard was the floor manager. Brooklyn Associations Nos. 8, 27, 41, 57, Melville Council No. 9, of the Universal Craftsmen and the Modern Science Club, comprise the Combined Associations of Brooklyn.

BUSINESS ITEMS

Floyd F. Woods has been appointed sales manager for the Epping-Carpenter Pump Co., of Pittsburgh, Penn., taking the place of R. Bowen, who is no longer connected with the company.

The Mountain Ice Co. is putting a 219 kv.-a. Terry turbo-alternator set in its plant at Gouldsboro, Penn., and the Excelsior Needle Co., which is adding a new three-story building to the plant at Torrington, Conn., is installing a 375 kv.-a. Terry turbo-alternator set.

Gifford-Wood Co., Hudson, N. Y., is issuing a booklet containing a valuable article on the Basin Saw and its value to the ice harvester, by Frank H. Abbey. It is a well illustrated educational article and is sent free to anyone interested in ice and harvesting of ice.

Warren Webster & Co., Camden, N. J., has just issued a 64-page book which should interest every power-plant man. The title is "Heating the Manufacturing Plant by the Webster System." It illustrates plant after plant in which the Webster Vacuum System of Steam Heating is used, and gives in industrially classified form the names of a large number of concerns which have adopted it. Copies of the book are sent on request.

The Brown Instrument Co., of Philadelphia, has just moved into its new shops at Wayne Junction, where it has increased and improved facilities for the manufacture of its instruments of precision, such as pyrometers, voltmeters, ammeters, etc. It is most interesting to see how modern machine-shop methods and development have been applied to this line of work, which requires the maintenance of delicate standards and the preservation of cleanliness and accuracy, and visitors are always welcome.